

PROCEEDINGS
AND
TRANSACTIONS
OF THE
LIVERPOOL BIOLOGICAL SOCIETY.

VOL. XXXVIII.

SESSION 1923-1924.

PRICE—ONE GUINEA.

LIVERPOOL :
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 1917—1918 JOSEPH A. CLUBB, D.Sc.
 1918—1919 PROF. W. RAMSDEN, M.A., D.M.
 1919—1920 HUGH R. RATHBONE, M.A., J.P.
 1920—1921 PROF. P. G. H. BOSWELL, O.B.E., D.Sc.
 1921—1922 HERBERT R. RATHBONE, B.A., C.C.
 1922—1923 PROF. W. J. DAKIN, D.Sc., F.Z.S., F.L.S.

SESSION XXXVIII, 1923-1924.

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 W. H. POTTS, B.A.
 COLLINGWOOD WILLIAMS,
 B.Sc.

Representative of Students' Section :

Miss E. PHILLIPS B.Sc.

REPORT OF THE COUNCIL.

It is with deep regret that the Council records here the death, on 21st July, 1924, of our Vice-President, Sir William Abbot Herdman. In the course of its existence, which extends now over thirty-eight years, the Society has, of necessity, experienced the loss of many of its original members : some because of death, or retiral from active biological work, and others because of their removal from this city to other fields of work. Such losses as those of Mr. Isaac Cooke Thompson, Mr. Joseph Lomas, Professor Benjamin Moore, Mr. Arnold Watson, Professor Harvey Gibson, and Sir Charles Sherrington have indeed, been grievous ones, yet none of them has affected the work of the Society in the same measure as that which the Council now deplores.

Sir William Herdman was the founder of the Liverpool Biological Society : its first President and, since its formation, its almost continuous Vice-President. He came to Liverpool, in 1881, to take office in the University College as the first Professor of Natural History. In Liverpool he found a small group of enthusiastic naturalists who were working without much guidance and without any definite object and these men and women he made into useful investigators. The Biological Society, which met for the first time, in the Zoological laboratory of the College on December 11th, 1886, was one of the results. A year earlier, on 14th March, 1885, he had assembled together representatives of the scientific Societies and Museums of Liverpool, Manchester and Chester, and the result of this meeting was the foundation of the Liverpool Marine Biology Committee. Then followed the establishment of the Puffin Island Biological Station and, a few years later, that at Port Erin, in the Isle of Man. The Lancashire Sea Fisheries Committee was also persuaded to found and maintain a Fisheries Biological Station at Piel, in Barrow, and a laboratory in the University College of Liverpool.

The fisheries station and laboratory were provided officially, but the Liverpool Marine Biology Committee and their friends built, equipped and maintained the stations at Puffin Island and Port Erin and found the money for the many dredging expeditions that were organised. The result was a complete investigation of the fauna and flora of the Irish Sea region and the results of this are recorded in the Transactions of the Society. The Society itself was the rallying point for all those engaged in this work of investigation and who were generally interested in the study of biology.

Throughout this period of thirty-eight years Sir William Herdman was a continual stimulus to the work of the Society. He was a man who had many other duties and interests. His work at the College was important and onerous, especially during the years immediately before and after the foundation of the University of Liverpool. His first years of work there were preoccupied with the description of the collection of Tunicates made by the "Challenger" Expedition. He was for many years a member of the Executive Committee of the British Association: he was a member of the Council of the Royal Society and, for some years he was its Foreign Secretary. He was Scientific Adviser to the Lancashire Sea-Fisheries District Committee; he was a member of several Government Committees of enquiry and he gave evidence before Royal Commissions and Departmental Committees. Added to all that was his work on the Ceylon Pearl Fisheries, which caused him to make two expeditions to the Indian Ocean and to edit a report in five large volumes. Yet, with all this to do, he continued faithfully to attend the meetings of the Biological Society, and there were very few field expeditions at which he was not present.

During his life he received many honours. He was a Doctor of Science in the Universities of Edinburgh, Harvard, Durham, Sydney and Western Australia; a Doctor of Laws in the University of Edinburgh: he was a President of the

SUMMARY OF PROCEEDINGS AT THE MEETINGS.

The first meeting of the thirty-eighth session was held at the University on Thursday, October 11th, 1923, the President, Professor W. J. Dakin, D.Sc., F.Z.S., F.L.S., in the chair.

Mr. J. C. Waller, B.A., gave a lecture on "Photo-Electric Phenomena in Leaves," and exhibited the apparatus he used in his experiments.

Miss E. C. Herdman read a short paper recording her further investigations regarding the Dinoflagellates found at Port Erin.

The second meeting of the thirty-eighth session was held at the University on November 15th, 1923. The President occupied the chair.

1. The Report of the Council on the Session 1922-23 (see "Proceedings," Vol. XXXVII, p. vi) was submitted and adopted.
2. The Treasurer's Balance Sheet for the Session 1922-23 (see "Proceedings," Vol. XXXVII, p. xiv) was submitted and approved.
3. The following Office-bearers and Council for the ensuing Session were elected :—Vice-Presidents, Professor J. Johnstone, D.Sc., Professor McLean Thompson, D.Sc. ; Hon. Treasurer, W. J. Halls ; Hon. Librarian, Miss May Allen, B.A. ; Hon. Secretary, W. Rimmer Teare, A.C.P. ; Council, Mrs. Bisbee, M.Sc., S. T. Burfield, B.A., M.Sc., J. W. Cutmore, G. Ellison, Miss Alwen M. Evans, M.Sc., Miss E. C. Herdman, Professor Sir William Herdman, C.B.E., D.Sc., F.R.S., Angus Johnstone, W. S. Laverock, M.A., B.Sc., R. C. Moore, M.A., M.Sc., M.Ed., W. H. Potts, B.A., Collingwood Williams, B.Sc.

4. A lecture was given by Professor J. Johnstone, D.Sc., on "Fish Preservation and Food Supplies." Professor Johnstone also presented the reports of the Oceanographical Department and the Port Erin Station (see "Transactions," pp. 29 and 85).
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The third meeting of the thirty-eighth session was held in the University on Thursday, December 3rd, 1923, Sir William Herdman in the chair.

The President delivered a lecture on "The Teaching of Biology" (see "Transactions," p. 1) and on the conclusion of his address was accorded a hearty vote of thanks on the motion of Mr. Whitehead, of the Liverpool Education Committee's Staff, seconded by the Rev. Bertram Lee Woolf and supported by Mr. R. C. Moore and the Chairman.

The fourth meeting of the thirty-eighth session was held on Thursday, 17th January, 1924, the President in the chair.

Professor Sir William Herdman read a paper on "Huxley as a Biologist," and included in his remarks many interesting personal reminiscences.

The fifth meeting of the thirty-eighth session was held, in association with the Heredity Society, in the University on Thursday, 14th February, 1924, the President in the chair.

T. A. Coward, Esq., M.Sc., of Manchester, lectured to a large audience on "The Migration of Birds."

On the motion of Mr. E. Fry, seconded by Mr. J. W. Cutmore, the lecturer was heartily thanked for his address.

The sixth meeting of the thirty-eighth session was held at the University on Thursday, March 13th, 1924, Mr. W. S. Laverock in the chair. Mr. S. T. Burfield, B.A., M.Sc., gave

an address on "Some Considerations, Physical and Mathematical, on the Forms of Some Animals and Their Parts," and illustrated his remarks by some striking demonstrations.

The seventh meeting of the thirty-eighth session was held on 8th May, 1924, and took the form of a Soirée and Exhibition of objects of biological interest by the members and the staff of the Zoology Department. There was a very large attendance, and the meeting proved very successful.

The President gave a short lecture on "Leonardo da Vinci," illustrated by slides and by exhibits. He showed that this many-sided genius had a claim to rank as a biologist of considerable distinction.

On June 14th the Society took part in the joint excursion of Learned Societies to Halkyn Mountain, and on June 28th several members took advantage of the kind invitation of the Geological Society and paid a visit to Hilbre Island in company with the geologists.

W. S. Laverock, Esq., M.A., B.Sc., was chosen for nomination as President for 1924-25, and Dr. Clubb was appointed delegate to the British Association Delegates' meeting at Wembley.

LIST of MEMBERS of the LIVERPOOL
BIOLOGICAL SOCIETY.

SESSION 1923-1924.

A. MEMBERS.

(Life Members are marked with an asterisk.)

ELECTED.

- 1908 Abram, Prof. J. Hill, M.D., F.R.C.P., 74, Rodney Street,
Liverpool.
- 1919 Adami, Dr. J. G., F.R.S., Vice-Chancellor, The
University, Liverpool.
- 1909 *Allen, Miss May, B.A., HON. LIBRARIAN, University,
Liverpool.
- 1913 Beattie, Prof. J. M., M.A., M.D., The University,
Liverpool.
- 1915 Bisbee, Mrs., M.Sc., Zoology Dept., The University,
Liverpool.
- 1903 Booth, Chas., Cunard Building, Liverpool.
- 1919 Boswell, Prof. P. G. H., O.B.E., D.Sc., The University,
Liverpool.
- 1912 Burfield, S. T., B.A., M.Sc., Zoology Department,
University, Liverpool.
- 1886 Chubb, J. A., D.Sc., Free Public Museums, Liverpool.
- 1920 Dakin, Prof. W. J., D.Sc., F.L.S., PRESIDENT, The
University, Liverpool.
- 1910 Ellison, George, 52, Serpentine Road, Wallasey.
- 1918 Evans, Miss Alwen M., M.Sc., School of Tropical
Medicine, University, Liverpool.
- 1921 Fletcher, Miss Isabel, The University, Liverpool.
- 1922 Fry, Edward, 89, Penny Lane, Liverpool.
- 1902 Glynn, Prof. Ernest, M.D., F.R.C.P., 67, Rodney Street.
- 1886 Halls, W. J., HON. TREASURER, 2, Townfield Road,
West Kirby.
- 1922 Heilbron, Prof. I. M., D.S.O., D.Sc., The University,
Liverpool.
- 1886 Herdman, Prof. Sir William, C.B.E., D.Sc., F.R.S.,
University, Liverpool.

- 1921 Herdman, Miss E. C., The University, Liverpool.
- 1912 Hobhouse, J. R., 19, Ullet Road, Liverpool.
- 1902 Holt, Dr. A., Rocklands, Thornton Hough, Cheshire.
- 1903 Holt, Richard D., India Buildings, Liverpool.
- 1920 Johnstone, Angus, 63, Church Road, St. Michael's, Liverpool.
- 1898 Johnstone, Prof. James, D.Sc., VICE-PRESIDENT, University, Liverpool.
- 1918 Jones, Philip, Brantwood, St. Domingo Grove, Liverpool.
- 1896 Laverock, W. S., M.A., B.Sc., Free Public Museums, Liverpool.
- 1915 Macdonald, Prof. J. S., B.A., F.R.S., The University, Liverpool.
- 1922 McDonald, Dr. Archie W., L.R.C.P., L.R.C.S. (Edin.), Glencoe, Huyton.
- 1917 Milton, J. H., F.G.S., Merchant Taylors' School, Great Crosby.
- 1904 Newstead, Prof. R., M.Sc., F.R.S., University, Liverpool.
- 1913 Pallis, Mark, Tatoi, Aigburth Drive, Liverpool.
- 1915 Prof. W. Ramsden, M.A., D.M., University, Liverpool.
- 1921 Rathbone, Herbert R., C.C., 35, Ullet Road, Liverpool.
- 1903 Rathbone, Hugh R., M.A., J.P., Greenbank, Liverpool.
- 1890 *Rathbone, Miss May, High House, Leaves Green, Keston, Kent.
- 1923 Saunders, Prof. Carr, M.A., School of Social Science, The University, Liverpool.
- 1894 Scott, Andrew, A.L.S., Piel, Barrow-in-Furness.
- 1908 Share-Jones, J., D.Sc., F.R.C.V.S., University, Liverpool.
- 1886 Smith, Andrew T., Solna, Croxteth Drive, Liverpool.
- 1920 Southwell, T., M.Sc., School of Tropical Medicine, University, Liverpool.
- 1903 Stapledon, W. C., Annery, Caldy, West Kirby.
- 1915 Teare, W. Rimmer, A.C.P., HON. SECRETARY, 12, Bentley Road, Birkenhead.
- 1903 Thomas, Dr. Thelwall, 81, Rodney Street, Liverpool.
- 1905 Thompson, Edwin, 6, Livingstone Drive, Liverpool.

- 1921 Thompson, Prof. McLean, D.Sc., VICE-PRESIDENT, The University, Liverpool.
1889 Thornely, Miss L. R., Hawkshead, Ambleside.
1920 Walker, Prof. C., D.Sc., M.R.C.S., The University, Liverpool.
1922 Williams, Collingwood, B.Sc., Lynton, Cressington Park.
1920 Yorke, Prof. Warrington, M.D., School of Tropical Medicine, University, Liverpool.

B. ASSOCIATE MEMBERS.

- 1916 Atkin, Miss D., High School for Girls, Aigburth Vale, Liverpool.
1922 Braithwaite, W. G., 10, Plimsoll Street, Liverpool, E.
1922 Chenery, M.B., 9, York Avenue, Somerville, Wallasey.
1922 Clarke, J., Varna, Hawthorn Road, Moreton, Cheshire.
1914 Cutmore, J. W., Free Public Museums, Liverpool.
1922 Evans, C. E., 84, Boswell Street, Liverpool.
1922 Fell, W., Willaston, Birkenhead.
1922 Fordham, Miss M. G. C., B.Sc., Zoology Department, The University, Liverpool.
1922 Garnett, Theodore, M.A., South Bank, Grassendale.
1916 Gleave, Miss E. L., M.Sc., Oulton Secondary School, Clarence Street, Liverpool.
1922 Hayward, Miss, 30, Belvidere Road, Liverpool.
1922 Johnson, W., Highfield, Cliff Road, Wallasey.
1922 Jones, T. A., 27, Rockfield Road, Anfield.
1920 Kewley, Miss Helen C., 9, Cranbourne Avenue, Birkenhead.
1923 Kendall, Rev. C. E. Y., B.A., 79, Kingsley Road, Prince's Park, Liverpool.
1922 Legge, Miss C. M., 3, Grove Park, Liverpool.
1922 Lewis, Miss M., B.A., Oceanography Dept., University, Liverpool.
1919 Mayne, Miss C., B.Sc., 17, Laburnum Road, Fairfield.
1923 McDonald, Miss C., Glencoe, Huyton.

- 1922 Moore, R. C., M.A., M.Sc., M.Ed., A.I.C., 25, Galloway Road, Waterloo.
- 1922 Mounsey, Miss G., St. Margaret's Hostel, Princes Road, Liverpool.
- 1922 Muskett, T., 101, Gwladys Street, Walton, Liverpool.
- 1922 Porter, Charles, 10, Wellington Terrace, Liverpool.
- 1922 Potts, W. H., B.A., Dept. of Entomology, The University, Liverpool.
- 1922 Roberts, John E., 17, Darley Drive, West Derby.
- 1923 Staidler, Miss E. M., B.Sc., 4, Mount Pleasant, Liverpool.
- 1917 Swift, Miss F., B.Sc., Queen Mary High School, Anfield.
- 1922 Waller, J. C., B.A., Physiology Dept., The University, Liverpool.
- 1922 Warhurst, Miss E., L.L.A., 3, Argyle Road, Anfield.
- 1922 Williams, Miss E., 31, Egerton Road, Wavertree.
- 1912 Wilson, Mrs. Gordon, High School for Girls, Aigburth Vale, Liverpool.
- 1923 Wilson, Miss M. I., 7, Devonshire Road, Prince's Park, Liverpool.
- 1923 Woolf, Rev. Bertram Lee, M.A., B.Sc., B.D., Toxteth Manse, 7, Waverley Road, Dingle.

C. UNIVERSITY STUDENTS' SECTION.

President : Miss E. Phillips, B.Sc.

Secretary : Mr. H. Lister, B.Sc.

(Contains about 30 members.)

D. HONORARY MEMBERS.

S.A.S., Albert I., Prince de Monaco, 10, Avenue du Trocadéro, Paris.

Bornet, Dr. Edouard, Quai de la Tournelle 27, Paris.

Fritsch, Prof. Anton, Museum, Prague, Bohemia.

Hanitsch, R., Ph.D., Oxford.

THE LIVERPOOL BIOLOGICAL SOCIETY:

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IN ACCOUNT WITH W. J. HALLS, HON. TREASURER.

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„ Cash in hand.....	2	2	7
„ Balance in Bank.....	5	0	1

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Audited and found correct,

S. T. BURFIELD

INAUGURAL ADDRESS
ON
THE TEACHING OF BIOLOGY IN SECONDARY SCHOOLS

By PROFESSOR W. J. DAKIN, D.Sc., F.Z.S.
President

Delivered December 3rd, 1923

INTRODUCTION.

The subject which I have taken for my address this evening should be one of interest not only to members of this Society but to all who are interested in modern schemes of education. I have great hopes that some of them will read it in print, and if they agree with my attitude will become active propagandists.

I appeal also to those who may find something familiar in the title. Not that I find it difficult to treat the matter from a fresh point of view. It is, however, surprising, considering the voluminous literature of the subject (which is chiefly American) that so little of the information seems to be generally known, so much is neglected in practice.

One often hears the schoolmaster complain that many of the essays and reports from those who are not engaged in school teaching fail altogether to realise the school's point of view. The University Professor may often retort that those who mutilate his subject in the schools are not only unqualified to teach it but procure their information doubly second-hand from text-books written by pot-boilers.

My interest in the schools has always been a live interest, because almost all the students who have been through my hands have entered the teaching profession. This has brought me into close touch with school life in Australia as well as Europe. And in both parts of the world events have made me a member of a board conducting school examinations. Both in England and in foreign parts (Australia, Germany, Italy and Ceylon) I have visited many schools in quest of my information. Not only schools, for I cannot forget how, in a distant colony, I frequently had to state my case before an

after-lunch tribunal of squatters, lawyers and business men generally, in a rather worldly club where at least one interest in education (the financial interest) was very much to the fore.

In the United States of America, biology is recognised as a very important school subject—not for specialists, but as part of a general education suited for a democratic country of modern times. In Germany and France the subject is also realised to be of general importance and from the latest Government regulations for the French Baccalaureat (corresponding to our Matric.) it would appear that no candidate can escape taking some Natural History, i.e., the study of both animals and plants. Now it would be putting it mildly to say that in England the combined study of plants and animals is neglected in most schools, although one finds that in girls' schools its place is taken to a remarkable extent by the subject, botany. To my mind, this is not so much a modern development called forth by modern ideas as an extension of an early choice made in the sixties. It is a part of our natural conservatism.

Now it would be a mistake to advocate the replacement of botany by zoology or the introduction of animal biology as an additional full-time subject. On the other hand, it may be emphatically affirmed that it would be less invidious to split up physics and to take light as a separate school subject than to take botany alone—a subject which, until the later years of a University course, should be regarded as a part subject only—part of biology. By biology I mean the study of living things in the broadest sense.

A remarkable wave of enthusiasm for science passed over this nation during the dark hours of the war. From an examination of the debris left it would seem that many wise sayings in support of science teaching have been already forgotten, and there is a grave danger that science in schools will become as infertile as was compulsory classics in the hands of the uninspired teacher.

It is noticeable that science subjects with a supposed £ s. d. value have been receiving most attention. Where this is not the case the choice favours the science subject which appears most easily taught. The expected £ s. d. value of special school training does not always materialise—in fact, it is scarcely possible without very highly specialised training, and this is not for secondary schools. In any case, such a claim for a school subject is not ideal. Perhaps, however, it is a vain thing to ask for ideals in education ?

The development of a school subject depends, so far as I can follow it, permanently upon two bodies—the School with its governors, head, and teachers, and the Education Department. Unfortunately, a third possible control—public opinion, does not count for much in England.

Now the present position of biology is largely due to the schools and their governing bodies, but in schools where His Majesty's Inspectors are regarded as little lower than the angels the choice of science subjects may have been influenced by the following remarkable statement,* which I intend to criticise in this address :—

† “The principles of Biological Science can be better illustrated by means of botany, especially as physiology occupies a far more important part in this subject than in zoology, which does not readily lend itself to experimental treatment.”

This dictum is totally incorrect, unfairly stated (because details are lacking) and altogether biased (there was a remarkable preponderance of botany on the Committee).

My criticism will be launched under two heads—the first section being a statement of some of my reasons for regarding biology as a really important school subject, whilst

* It has already been severely condemned by a Committee of the British Association for the Advancement of Science.

† This appeared in the Reports of the Investigators, Secondary School Examinations Council, pub. 1919.

the second takes up the practical side of animal biology (the neglected part) as an experimental science.

Wishing to enter into the subject from the point of view of the schools and with a desire to some originality in treatment, I directed a questionnaire to a large number of secondary schools in the North of England. A few of the interesting and more characteristic replies from the schools are dealt with. Somewhat to my surprise, practically all my correspondents realised the value of biology as a school subject. I now gather that the actual inclusion of the subject in the curriculum is dependent upon more practical and less ideal factors! The second part of this address is specially directed to those who have raised practical difficulties.

PART I. THE IMPORTANCE OF BIOLOGY AS A SCHOOL SUBJECT.

In the scramble to state the claims of school subjects, the claims of biology have not been overstated. Possibly this is due to the fact that there are no professors of biology in our Universities!* Perhaps, however, it is just as well to leave the University dons and go elsewhere for support. The late F. W. Sanderson (the renowned headmaster of Oundle School) was one of those who glimpsed the truth when he said: "The importance of biology in a scheme of general education cannot be overstated. It is the science which very closely touches the life of the nation, and its economic value is found in all directions. Every branch of knowledge in the years to come will be influenced by the study of biology, and the humane studies in history, economics, sociology, will be rewritten under the same."

In another place, Sir Michael Sadler, after referring to the sciences in general, writes: "The more general introduction

* The subdivisions of biology are usually represented to-day by separate departments of botany and zoology, each with its own Professors—often more than one, so great is University specialisation.

of biology into school studies should, on educational grounds, be specially encouraged."

It would not be difficult to produce many similar statements from leaders whose views are worthy of the greatest consideration. The remarkable feature is that these and similar references produce so little result. Of course, if biology is to be regarded as just another examination test there is little more to be said. What beautiful theories are created and blazed forth by the advocates of the different curricula! What dead bones they become without their interpreters! A subject treated as some of our sciences are already being treated will become only another new branch of the old scholastic regime without the disciplinary results which were supposed to be amongst the attributes of the older classical education.

It has been granted that all the sciences have a like *general* value in education, based upon their common use of similar mental operations. This value is well known and consequently need not be reviewed here. The aim and method of science has been summed up by Karl Pearson as a training of the mind to an exact and impartial analysis of facts. This may be extended by pointing out that "science differs from other studies in that it has to do with objective realities and our intellectual interpretations based upon them." But each science has *special* values and I am of opinion that, after granting the general value, we should look with more interest at these special values when inventing a curriculum. It is the special values alone of biology that I shall plead here.

It is peculiarly true of biology that it enters into the most intimate relations with all human life, but there is no truth in this assertion if biology is stripped of its animal section. Man is an animal. The structure and functions of his body are typically animal. No amount of study of the nutrition

of a cabbage will help in the understanding of human digestion, nor will the study of the stomata of an onion leaf throw any light upon the function of mammalian skin. What plant possesses a heart, and where is the characteristic brain and nervous system? Where in plants do you find the muscular activities so typically animal and the means of locomotion which are so intimately correlated with the development of the wonderful animal sense organs? In school courses botany, taken alone, appears to me as half a subject, as a makeshift indeed, a relic of the past. Two pearls matching each other and making a pair become commercially each twice as valuable as they were singly; biology is far more than twice as valuable as its complementary subdivisions (botany and zoology) taken apart.

On every railway bookstall one sees books on animal and plant life, on health and on sex. Many of these are weird books by strange people, yet it is surprising what a big sale there is for literature of this kind, as well as for works on keeping fit, on neurasthenia, and so on. The public is craving, often too late, for knowledge which should have come earlier. The Workers' Educational Association established classes in Australia. The only subjects in keen demand up to the time I left were Economics and Biology. It is undoubtedly the animal side of biology which proves of the greatest interest to those who want to know more about heredity, evolution, and the relations of health and disease. But to be fair, what zoologist would discuss heredity without referring to the plant world and the experiments of Mendel.

If democracy is to govern better than the government of the past, it must be a trained democracy. Australia and America recognise civics as a school subject and America has always realised the relationship between biology and public welfare. I have one of their school text-books on civic biology here. The preface states that it is "A text-book of

problems, local and national, that can be solved only by civic co-operation." The point of view of the authors is illustrated by the following quotations—naturally, the details are American, but English equivalents are easily found: "In how many of our civic units does every citizen know enough to conserve effectively the valuable bird life, the trees, the soil, and water on his own premises, to exterminate the rats and English sparrows, the flies, mosquitos and San José scale, the hookworms, etc." "A would gladly protect his birds, but not to feed Mrs. Y's cats. C could easily exterminate his own flies, but they continually swarm over from D's filthy premises." "Civic biology consists in that group of problems in the control of living nature to solve which requires that a community unite in working together intelligently."

The flies, to take this as one example, are with us in England, and it is quite easy to study both the house-fly and bacteria in our curriculum in such a way that one will have achieved the following:—

(1) A training in experimentation and the handling of apparatus.

(2) A training in observation and deduction.

(3) A demonstration of beauty of structure (for even in the detested house-fly there is something which puts out of court the most wonderful piece of machinery).

(4) An imparting of information which is of importance to human welfare (including a very striking demonstration of the physical and moral value of cleanliness).

We cannot afford to ignore work of such a character—work which supplies all that the most academic will claim for a school subject, and which, at the same time, provides knowledge which can serve as a fuller preparation for life. It would be extremely difficult to make such a strong claim for any other science. Only the other day a medical writer stated that "The student of preventive medicine knows full well that,

after all the achievements of public hygiene, in the field of sanitation, drainage, food inspection, control of infection, vermin destruction, and so forth, there remains and always must remain the field of personal hygiene, where the habits of the individual determine his fate, and may, if contrary to the laws of life, speedily destroy him, even though an extra ministry of health be installed every day in the week."

It was falsely stated that animal biology or zoology could not be made experimental. The study of animal digestion supplies all the opportunities for simple and inexpensive experiments that one could wish, quite apart from the valuable lessons which result such as some knowledge of animal nutrition, respiration and excretion. The pupils can now be made to realise that that which is guarded by instinct or restricted by structure in most animals and plants is open to serious damage in man by reason of his power to choose, and by the possibility of exercising his functions for good or evil. Following out this line of thought, I am led to another very important aspect of teaching—the oft-debated question of education in matters appertaining to sex. I am not going to discuss this here; I have dealt very thoroughly with it elsewhere and in conjunction with a medical man. I am not even going to ask you to accept this matter as part of my programme, but it must be mentioned.

It is generally agreed now that the young should not be left to gain sexual knowledge in any promiscuous fashion. The parents are, of course, responsible and should carry out their duties. But how many of them do so—how many are able? Yet some, and often the least capable, make the loudest objections to anyone else endeavouring to perform what is necessary.

Undoubtedly we are up against one of the greatest educational problems of to-day. Biology offers an excellent way out of the impasse that has been reached, and, in brief,

it is the following : Take biology as a complete unit. You will then have described the different means of reproduction in many selected animals and plants and in a natural manner. Some of the most fascinating stories will have been told without arousing any morbid interest— we can vouch for this in the Universities, where our mixed first year classes have had this section of the subject for years. One can take a beautiful series of examples without ever discussing or mentioning man. Here, in most cases— probably all —you could stop. The intelligent child (of secondary school age) will realise the beauties and dangers of sex without any further discussion being necessary — probably better, in most cases. It should be sufficient to remind the pupil of those previous studies on nutrition, excretion, the skin, respiration, the muscles, etc., when the comparisons between man and the lower animals ought to have been made. Man has been given the power of choice—it is the natural sequence that he should have to learn. One can overeat or overdrink—can use the wrong foods—can take too much exercise or too little The position is self-illuminating. If someone—a headmaster, a doctor, or a parent, has to go further — think of the foundation already provided and the extreme ease of the next step.

I fear I have been rather blatantly practical, now let me touch on some other special advantage of biology as a school science ; reasons of another kind for its encouragement.

Is it not true that children have a normal and natural craving for the study of animal biology unless it has been repressed ; in other words, “ educated ” out of them ? A glimpse into the catalogues of a library or a visit to a large book shop at Christmas time is sufficient to demonstrate the call for books dealing with animals. I do not mean exactly such books as *Life in ponds and streams* or *British birds' nests*, which have indeed a ready sale, but the books like Kipling's *Just So Stories*, the *Jungle Books*, the *Bad Boys' Book of Beasts*,

and so on. I am also reminded of the hosts of jolly children who crowd the London Zoo and invade our museums, notwithstanding the fact that most of the latter are fusty, dingy places, only describable by a writer like Dickens. The children of Munich are the ones who can enjoy museums, but that is another story!

There is a great movement in England, one of the finest of this generation—copied by the Empire, emulated in fact by all the world—the Boy Scout movement. I wonder whether our Government inspectors and some of our routine teachers realise the part played by natural history studies in this movement? It may be that I have seen it on the heather-covered hillsides, but not all the English schools are situated in industrial centres, and certainly the scholars of secondary schools are not unable to make little excursions into the country. A cheap camera, a few films, and a little pocket money for excursions into open country, combined with a little encouragement and the knowledge of how to make nature studies with the camera instead of the gun would provide more pleasure and health for our young people than many other hobbies or city entertainments. This was my opinion before I heard from the schools. I am a still greater believer now. Listen to the following:—(1)* “A further reason is the fact that in Birmingham the natural tendency is to stress physics and chemistry *as being more suited to the industrial bent of the city.*” (2) † “The natural leaning of the Sheffield child is to neither plant nor animal life. They live on steel, and what steel stands for.”

There it is—think of the mills that will grind you to powder—even before you are fully fledged! Is this the beginning of Rossums Universal Robots? God forbid! If industry is going to play such a part in the after-life of our

* Extract from a letter from a Birmingham school.

† Extract from a letter from a Sheffield school.

boys and girls attending secondary schools, there is all the more need that they should have some training in a science that will teach them how to live.

Many years ago I heard Professor Campagnac pleading for a new spirit of reverence. How much more is it necessary to-day? Taken properly, the science of biology could be utilised to a wonderful extent to encourage that spirit. I am not the first to touch upon the aesthetic value of both branches of biology, but the aesthetic side is too often forgotten—many don't realise that there is a beautiful side to animal studies. Huxley was very outspoken regarding this and Haeckel (the German Huxley) published the book from which I have taken the very beautiful illustrations (*Art Forms in Nature*—projected on screen).

Some critics may say that the cultivation of an appreciation of the beautiful in nature is not pure science. Fortunately, it is actually part of the science of biology and the interpretation of natural beauty may be most scientific (*Colour and Form in Nature*). As Bigelow pointed out, aesthetic studies are part of the normal value of biology and no rightly trained student will value animal life lightly. It is usually the biologist who asks for animal protection.

I have already made a few remarks about the exaggerated statement of His Majesty's Investigators that zoology does not lend itself to experiment. This will be dealt with more fully in the succeeding pages. In the meantime, a warning is necessary. The study of science must not be regarded as merely a series of experiments with a few bits of glass tubing, a balance and some chemicals in a laboratory. Is observation and deduction only to apply to bits of plants torn from their native environment, or to the colours produced by dropping chemicals on a bit of potato, or again, to the smells emerging from a test-tube? I hope I have provided you already with an answer. Biology is, of course, unique in the oppor-

tunities it offers for observation (think of Fabre, Réaumur, and the older naturalists, as well as the modern). Let me remind you of a remark of Emerson—"I am impressed with the fact that the greatest thing a human soul ever does in this world is to see something and tell what it saw in a plain way. Hundreds of people can talk for one who can think, but thousands can think for one who can see. To see clearly is poetry, philosophy and religion all in one."

PART II. PRACTICAL METHODS OF TEACHING ANIMAL BIOLOGY.

It is impossible to condense a course of lectures on the teaching of animal biology into half a lecture. At first I had the impression that there was no need even to consider attempting the impossible. I believed there was an ample supply of school text-books. I now realise firstly that most of these books are unknown to teachers and, secondly, that no single book fits in with my scheme. Perhaps, in the near future, it may be possible for me to add another book to the series already published, which *will* embody a new view-point; in the meantime, I intend to take a few illustrative examples which will explain my methods and at the same time enable us to explore several practical questions which seem to be a disturbing influence in the schools.

My letter, which was sent to a large number of secondary schools in the North of England, put three questions. The first question asked why botany was selected in preference to biology (where such a choice had been made), the second asked whether any difficulties had arisen in teaching animal biology, and the third amplified the first question and inquired into local conditions.

To my surprise, practically no case was made for the restriction of teaching to botany. Many heads of schools acknowledged that they regarded biology as the better school

subject, but gave reasons for choosing botany in spite of this. The type of reason is indicated by the following :—

(1) “I agree that biology is a more complete subject than either botany or zoology alone, but botany is taken. (Note : It was a girls’ school.)

(a) Because it seems to be the general custom to teach botany in girls’ schools ;

(b) There is difficulty in obtaining sufficient quantities of animals for school work.”

2. Botany was chosen in the first instance because :—

(a) It was thought easier to obtain teachers of this subject ;

(b) Our laboratory accommodation was more suited to the one than the other.

3. “This year we have begun the teaching of biology in the fourth form, but we are doubtful of being able to offer it as an examination subject, as it requires double the time to teach both the study of animals and plants. We have also great difficulty in obtaining a suitable text-book for the animal section of Natural History.”

4. “I have discussed the subject with teachers from other schools and I have been under the impression that the equipment would be somewhat expensive and the specimens difficult to obtain.”

5. “Botany so far is much more in demand from the teaching point of view.”

Most of the views expressed in these extracts are open to the most severe criticism on educational grounds. They are valuable because they bring us into direct touch with those who choose and those who teach. Possibly the University Professor of botany might—with stately periods—have made a better case out for his particular subject. But, as likely as not, he would not be familiar with school practice.

It will clear the air and enable you to realise the difficulties which are to be overcome, if I commence with a brief criticism

of some of the most frequent objections to biology brought forward in the replies to my questionnaire. No. 1: "Botany is chosen because of the ease with which it may be taken up as an examination subject. Biology is a wide subject and requires more time to prepare students for the syllabus."

I am excessively tired of the examination point of view. We appear nowadays to be examination mad. We are not really considering the *needs* of our young people, unless the necessity of passing some examination or other may be regarded as such. And we become more able in this respect every year—our tests become harder, our syllabuses more extensive. But this increased ability to pass higher tests is largely due to more intensive cramming. No time is allotted for thought and we produce clever examinees but unintelligent people. Is this going to be a reason for not accepting biology? What about the children who don't want examinations and don't want University degrees—but desire only a training for life?

That is the proper answer to the objection. But perhaps it will appeal more to some of my hearers if I say that the statement is incorrect: biology does not require more time than botany. The science syllabuses set in the school examinations are supposed to require about the same length of time and to be of equal difficulty. The paper on zoology or botany is supposed to be twice as difficult as the corresponding half of the biological paper. If such is not the case, the fault lies not in biology, but in the examiners.

Another answer supplied two or three times in different disguises submitted that many children were going to be teachers and there was a greater demand for teachers of botany.

It would appear from this that the main reason for teaching botany was to make posts for teachers of botany who, in their turn, would advocate their subject in order to get material to teach. Apart from the "trade" criticism.

one might indeed ask for a more melancholic example of a vicious circle.

Here is another reply -“ We thought there would be a difficulty in getting teachers of animal biology.” This encourages one to ask why the writer did not go a little further than thinking. Of course, if the teachers were expected to take biology, Spanish, higher mathematics, with music in spare time, I doubt if University trained graduates would be forthcoming.

“ Girls did not like handling animals.” “ The teacher thought handling and dissecting animals might make the children callous ” (Note -She had apparently not tried to find out).

I am very glad to have this point brought forward and for the information of those who are still timid let me say that dozens of teachers and many heads of schools taking animal biology have found the reverse to hold good. In many cases where the belief is held it is due simply to a personal dislike to handling animals on the part of the head of the school or the untrained teacher asked to take the subject. You cannot expect successful teaching if the teacher dislikes the work ; no subject will flourish in an antagonistic atmosphere. Yet I have heard of Honours History students being asked to take science !

Here on the table I have all the types which are usually dissected in schools. If a girl is too fastidious to touch these it is surely the duty of the school to help overcome such feeling as part of a preparation for after-life. Do you want me to believe that following out the nerves of a crayfish with fine needles is more distasteful than cutting up a lobster in the kitchen or that it is going to lead to a more callous attitude to animal life ? There are, I must admit, certain animals which might be disliked—but why choose them for a school course ? I myself would not include either the cockroach or the rabbit

except for Advanced Higher School Certificate classes where I knew that I had enthusiastic pupils, ready and desirous of going ahead.*

Besides, distaste is easily overcome. You cannot afford to cut out desirable work because, for the first hour of the first day, a student brought up under certain conditions dislikes to handle a specimen. I am afraid some of the objections (which perhaps I have stressed too much) are a sign of narrow upbringing. There is a reminiscence in it of the note received by a head-mistress of my acquaintance—"Please don't teach my Maggie anything more about her inside, 'cos it's rude." It came from a mining community not far from Wigan. I am also reminded of the numerous Liverpool parents who send their boys to become mere clerks in offices because it is such an "eminently respectable" walk in life.

A much more serious item is the question of material, and here I *do* sympathise with many of my correspondents who are troubled by the expense and difficulty of procuring material for animal biology. This apparent obstacle is partly a feature peculiar to England, but it is also due to a fault or rather a lack of vision on the part of the Universities. The difficulty is not altogether real and the subsequent pages should show how it can be, and actually is, overcome. But we have been proceeding too fast. Dissection is only a part of biological methods. There are many animals where almost the entire structure of the body can be seen in the transparent living specimen. In other cases, a study of external characters only is required. Nor is this all, for the study of function is most important and the observation of the habits of living creatures is a most essential part of our subject. It is necessary to steer a course between the older natural history methods and the more recent purely laboratory studies involving much emphasis of structure and little of function.

* Since writing this address I find that some successful teachers in girls' schools disagree with this view-point and say that there is nothing difficult about taking the rabbit. All the more credit to them. It is a reflection of good teaching.

The first rule for guidance in teaching should be to keep the subject from becoming a series of isolated studies. At present there is a tendency to cram up a certain amount of information about one animal and then the next type is taken in the same way. Nor is it correct to keep the botanical and zoological sections of the subjects absolutely distinct. The result may be satisfactory if stereotyped examination questions are to be answered, but it is not education and the system fails badly if unexpected questions are set.

I consider that the whole subject of biology should be regarded as a vari-coloured fabric through which two silver threads are everywhere interwoven. One of these represents the fundamental nature of the life processes, such as respiration, nutrition, excretion, reproduction, and sensitivity. The other is the relationship of the study to human life and social welfare.

It will be found rather difficult to pick out and study these threads alone, although a scheme of this kind has been suggested as the modern method. One cannot very well take up the function of respiration, for example, and study it in a comparative manner in plants and animals of different species. With unlimited time and money it might be done. In the practical class a study must be made of one animal type at a time (except in a few cases) and this study has to be as complete as possible (it is determined by the practice of economy in the supply of specimens) before passing on. There is no reason why lectures should follow the same plan. As an experiment I would suggest that the practical studies be accompanied by a little more information than is usual in practical classes and be therefore more complete. The lecture-demonstration classes might then be run on different lines, with more attention to my silver threads—especially the idea of unity of function.

In a two years' syllabus both plant and animal studies should be taken each year. Probably it would be found advantageous to keep a little more to the study of types in the first year and more to a study of functions during the

second. These things must be left to the individual teacher, but in any case, where the type study is followed there should be more comparison, more realisation that the "machinery" packed away in the tiny water flea is representative and performing the same functions as the machinery packed away within the giant whale and the medium-sized human being.

How to actually *commence* the teaching of animal biology is perhaps the most difficult problem of all. After many years of teaching, I am convinced that one must begin with the concrete and with something not too far removed in structure from the vertebrate. I should therefore take two types in detail and these would be the crayfish and the frog. They provide an introductory and very thorough training on two contrasted types—the arthropod and the vertebrate. It must, of course, be realised that crayfish cannot be produced by a wave of the wand. The season for both animals is spring, and this should be taken into account by teachers when planning their courses or at least when ordering their material. It is no excuse whatever to say that you cannot take animal biology because the material cannot be obtained, or only with difficulty, when that excuse simply implies lack of plan—how do some schools manage it, and how do the Universities get along?

During the time remaining at my disposal let me take briefly, and at random, a few examples from a school course with a view to showing how animal biology can be directed along experimental lines, and with some indication of the cost.

How many schools (with biology laboratories) cultivate *Amoeba*? Very few, I imagine. Yet it is quite easy to have a culture always at hand so that the pupils may examine specimens at any time. All that is necessary is a glass tumbler and a few wheat seeds plus a few amoebae to start the culture. There is often a little difficulty in getting the amoebae acclimatised at first, but once accomplished, there is no further

trouble. We put nine wheat seeds in 500 c.c. of water. The whole is raised to the boiling point and kept there for five minutes. The solution is then allowed to cool and is ready for the introduction of the amoebae. Every two months, when the culture is going well, we transfer some amoebae from it to a freshly-made wheat seed water and a new culture is started.

Cultures of *Paramoecium* can be made very easily indeed ; methods are described in many text-books. All this material costs practically nothing, yet with it one can study in detail examples of the protozoa (pocket editions of the higher animals), a group so important now in connection with disease. One can even experiment, for the effects of lack of oxygen, of variation in temperature, and of light can be observed.

How many teachers have tried feeding *Paramoecium* on hay bacteria stained with neutral red ? It is possible by this means to follow the digestive changes by watching the alteration of colour in the food vacuoles as the acid reaction becomes alkaline. Such work requires, of course, a compound microscope, which is not absolutely necessary for the lower forms. Why, however, should one fight shy of this extremely useful instrument (useful for both plant and animal studies) and begrudge the cost ? There is, apparently, a similar regret at the cost of purchase of a few cheap animals. It will take a very big biological outfit indeed to approach in cost the large sums so freely expended on the elaborate laboratory fittings, apparatus and chemicals required for physics and chemistry. Messrs. Ogilvy & Co., of London, will supply a new compound microscope suitable for school use for as low a figure as £7 13s. 6d. Without a high power, this would only be £5. Other firms would do the same, and there is always the opportunity of purchasing good second-hand microscopes if teachers would get into touch with University laboratory attendants.

Whilst on the subject of the protozoa, I am going to suggest what seems almost a new subject for the school biology curriculum—an experimental study of bacteria. The position of the group is such that it might be said to belong to either the animal or the plant kingdom, so that we are quite entitled to introduce it here. The bacteria are of immense importance in public life and but little understood by the general public. Most people have regarded their study as quite beyond school resources, apart from the use of a high-power microscope. The contrary is the case. One can see the colonies of bacteria grown as plate cultures with the unaided eye, and all that is necessary for the practical outfit is a few dishes, test tubes, cotton wool, litmus paper, gelatine (or agar agar), beef extract, one or two chemicals and something which would serve the purpose of a steam steriliser. A cupboard near hot-water pipes will serve quite well for an incubator. The pupils can easily demonstrate the universal distribution of bacteria and perform simple experiments to discover the degree of bacterial contamination about them. Dishes of culture medium may be exposed for five minutes in the laboratory before the class enters, and for a similar time immediately the class has left; after using a feather duster, a damp cloth, on the top floor and on the ground floor. A fly can be encouraged to walk across a sterilised agar plate, milk and water can be tested, and so on. There is enough experimental work in this connection for any lover of glass tubes and laboratory work. This study should, of course, be linked up with the work on the house-fly and with civic biology. The house-fly and bacteria are ubiquitous.

Many writers have stressed the importance of studying the animal life of some environment in the vicinity of a school and a place has been found for such studies in the Syllabuses of the Joint Matriculation Board under the heads of Woods and Hedges, Ponds and Streams, etc.

I do not think, however, that the full value as a school biology subject of a study of "plankton" has ever been realised in this country or in America. In Germany its possibilities have been utilised to a much greater extent in school courses. Seaside schools could study the marine or the fresh water plankton; inland schools would be compelled to take the latter.

By the fresh water plankton I mean that assemblage of organisms (plant and animal in nature) which is found floating in the waters of ponds, lakes or rivers—a little community which can be captured with a pull of a fine silk net. Many of the organisms which make up the assemblage can be easily cultivated in small aquaria. Quite apart, however, from studies of the individual creatures the plankton offers an excellent opportunity for the study of the interactions of living organisms, the relation of the producer to the consumer, and of both to the ever-changing environment. One can study the seasonal change, for springtime and harvest is as clearly marked in this aquatic community as along the roadside or in the fields. Numerous other possibilities occur to me.

A study of the adaptations to a floating life (such as the presence of spines, oil drops, gas vacuoles, etc.) and the changes in form which often occur during the year (correlated, no doubt, with changes in the viscosity of the water) can be correlated with physical phenomena. One can observe the effect of light and investigate heliotropic movements for some of these planktonic creatures are attracted by, whilst others shun the light. Another feature of the plankton of great practical value from our point of view is that the organisms are characteristically transparent and one can often perceive the muscles, alimentary canal with its glands, the gills, respiratory tracheae, nerves, etc., without any dissection, in the living organism in fact. In a Daphnid, for example, the heart can be seen beating, the food can be watched passing

through the alimentary canal and the meaning of peristalsis is demonstrated before one. If this is not sufficient, it is possible to "develop" the picture a little further by the addition of a very small amount of a dye such as neutral red, to the water in which the animals are living.

Finally, there are fascinating life-histories to be pieced together and remarkable features in reproduction (adaptations to meet the dangers of winter or summer). For higher classes in schools conveniently situated, the study of seasonal change in different ponds is not only easy but capable of supplying information of value to science if proper records be kept.

Now let me turn to another experimental side of animal biology, viz., the study of nutrition and respiration. I have not heard much of the experimental demonstration of animal nutrition in schools; it appears to be left usually to blackboard and chalk, whereas it is quite as easy to perform as experiments on plant nutrition. And it is probably much more easily understood by the children! The simple tests for sugar, starch and proteid can be explained just as they must be explained when plant physiology is being taken and without the necessity of any advanced knowledge of organic chemistry. One may then proceed to test the action of saliva on starch by adding a little human saliva to thin starch paste (made by heating starch in water in a test-tube). A previous test should have indicated the absence of sugar reactions in such a paste. After the mixture has stood a little time it should respond to the tests for sugar. With the aid of a simple apparatus for demonstrating osmosis it is possible to show that whilst the starch paste will not diffuse through a parchment membrane the sugar produced by the action of ptyalin can be detected on the other side of it. One can vary these experiments by boiling the saliva, by keeping the tubes at warm temperatures or on ice, and so on. In this way the students

can prove that starch does not diffuse through a parchment membrane, and that saliva prepares starches for absorption into the blood by conversion into sugar.

The action of saliva on proteids (such as white of egg) and on fats should be investigated next, and this would be naturally followed by experiments with pepsin. A little pepsin, a little HCl (enough to make the mixture slightly acid to litmus paper) and some insoluble proteids should be placed in a test-tube and kept near a radiator or warm pipes for a few hours. Use the simple osmotic apparatus as before, and test the water for peptone and proteins. Note whether undigested proteins such as albumen water, will diffuse through a membrane. Try the effect of alkali instead of acid. Use hard-boiled egg or minced cheese and lean meat. Similar experiments can be carried out with extracts of the so-called liver of the crayfish, lobster, or the common mussel. The secretions and digestive action of the pancreas can be shown by using crushed fresh pancreas extracted with glycerine (or pancreatic extract can be purchased).

These studies should be correlated with problems of human digestion, for they have a value in everyday life. Merely as a suggestion, I have here a table worked up by the Americans, which shows what I mean. It is possible that a more rational expenditure of money on food (where economies are very necessary) could be fostered in this way.

The study of respiration should be equally experimental. It is just as easy to keep a few caterpillars or a frog in the apparatus usually set up for demonstrating respiration in plants. The carbon-di-oxide given off in human respiration should also be made evident by breathing into lime water. The mechanisms of animal respiration provide one of the most excellent subjects for study, for it covers both observation and experiment. The finest ramifications of the respiratory organs of the aquatic insects can be seen in living

specimens. One manner of use can be studied in the mosquito larva and a model such as I have here will serve to make clear the part played by the surface tension of the water.*

Water currents directed over the gills of the crayfish (or into and out of the shell of a fresh-water mussel) can be made obvious by using a little carmine. The mechanism of inflating the lungs in the frog and the higher animals can be readily demonstrated with simple models and the description of human structure and function should be correlated with a demonstration of the methods of artificial respiration—very useful knowledge for anyone to possess.

One other example, just to illustrate my method a little further and this, the study of the vertebrate eye, would come under the heading of the nervous system and sense organs—a feature characteristically animal.

A poor teacher would draw a section of the eye and probably try to describe the different parts by reference to the picture. A good teacher would try and procure, for a few coppers, some bullocks' eyes from an abbatoir and give these to the class for dissection. But the excellent teacher, having done all this, would then make a comparison with a camera (some children will be found to have cameras in every secondary school now-a-days) and show how the lens throws an inverted image on the retina. Following up the comparison, he would show how focussing was necessary and how it was performed in the camera and in the human eye—in the latter case by demonstrating with a candle in a darkened room. The presence of a blind spot in the retina would be made clear

* A cork was weighted so that it floated below the surface and showed no sign of overturning. A glass tube about two inches long projected vertically upwards from the cork (the end pushed into the cork was closed, the other end was left open). By weighting the cork carefully with bits of metal it was possible to submerge the whole until the open end of the glass tube was really just below the level of the water surface. In this position the model was supported by the surface tension and resembled the mosquito larva when breathing. Drawing a fine camel hair brush over the top of the open glass tube sufficed to cause the whole to sink.

to everyone by the simple device of the sheet of paper with two black spots. The presence of retinal blood-vessels would be shown by looking at the sky through a card pierced with a pin-hole (the card meanwhile kept in slow circular motion), and so on.

I hope that I have said quite enough, and shown you sufficient on this table, to prove that animal biology *does* lend itself to experiment. There must be observation as well as experiment; nay, one must go a step further—there must be a certain amount of information given by the teacher regarding things which can neither be handled nor seen. The laboratory, the museum and the picture all have their place. I would not, for example, neglect a reference to that interesting animal, the whale, in a *senior* biology course, although it would appear that some writers would rather that the biology student left school believing it to be a fish or one of the main sources of petroleum, because it cannot be examined in the laboratory! This is carrying scientific method to extremes.

We have had (1) the cost; (2) the laboratory requirements; (3) the difficulty of obtaining material, brought forward as three obstacles to the adoption of animal biology as a school subject. Now it is not difficult to prove that this cost has been over-estimated. Unlike chemistry and physics, no elaborate laboratory is absolutely necessary—a room with water and gas available and level table tops is sufficient. Moreover, the same room is suitable for both botanical and animal work. As to the cost of animals, the teacher who understands his subject can provide much for nothing or a few pence. The most expensive items are the frog and the crayfish. Suppose you have an advanced class of 30 (which would be a large one), and that each child uses three crayfish and three frogs, the total cost would only be £3 6s. A supply of *Hydra* would cost about 2/-. Bullocks' eyes could be obtained gratis if you were friendly with a butcher (we pay 1d. each because we are

not friends). Pond material ought, in most cases, to be procurable for a small tram or railway fare, and cultures could be kept in aquaria in the laboratory. I am sure there has been some misconception regarding expense.

The third difficulty has been really serious—where are the animal specimens to be obtained? It has been made quite evident that teachers require help in this connection. I have already touched upon the impossibility of procuring material at the wrong season. If courses are correctly planned and material is asked for at the right time, the University laboratory attendants at most of our Universities—certainly Liverpool and Manchester—will be found excellent purveyors of animal types, and at very reasonable rates.

And now, in conclusion, let me touch upon a very serious aspect of my own experiences during the last two years. To follow out a syllabus with a view to obtaining the greatest examination success at the utmost minimum cost in teaching time is not education. I cannot help but feel that this is at the bottom of much of the criticism levelled at the teaching profession by business men during the past year. My reason for saying this is that students who come to the Universities now-a-days answer stiffer questions in Matriculation than they did twenty years ago, but they know less. Biology is just as good an examination subject as any other science, but I have tried honestly to write this paper as one who believes that biology is especially necessary in the schools for a complete education. The bulk of our children are not going to attend Universities at all, and they don't want botany, biology, chemistry, or any other subject in order to enable them to pass University examinations or to become teachers.

The subjects of a curriculum ought to be regarded far more as a part of a training for life. To tell me that you teach botany merely to produce teachers of botany is an indication of something rotten at the core. I cannot believe

things are as bad as that, although I do feel that we are examination mad. Unfortunately, there seems an increasing tendency to cram and not to educate.

Let me remind you of the words of the Holy Lama in Kipling's *Kim*—they may be taken as a warning: “Education is greatest blessing if of best sorts. Otherwise no earthly use.”

THE
MARINE BIOLOGICAL STATION AT PORT ERIN,
BEING THE
THIRTY-SEVENTH ANNUAL REPORT

DRAWN UP BY
PROFESSOR JAMES JOHNSTONE, D.Sc.
(Department of Oceanography, University of Liverpool).

INTRODUCTION

The year 1923 has been a successful one with regard to the further equipment of the Station and the scientific research carried on in connection with it. Various changes, leading to the greater efficiency of the Institution have been effected. The University of Liverpool has now appointed Mr. W. C. Smith as Curator, with charge of all administrative and routine research matters, and this arrangement leaves Mr. J. R. Bruce free to give his whole time to pure research work. Mr. Smith has also been able to give some attention to fishery investigation in connection with the Insular industry, and is now in touch with the work of the Sea Fisheries Board.

Progress has also been made with the general equipment of the Station for specialised research work. The Bio-chemical Laboratory has received considerable attention from Mr. Bruce, and now offers facilities for most kinds of biological investigation based on chemical methods. Three comfortable work-rooms for members of the staff, or visitors, have been fitted out. The Library has been much improved and additions to the collection continue to be made. A start with the renovation of the Museum has been made but, at present, the materials for the satisfactory exhibition of specimens are very expensive and the progress is slow.

The financial condition of the Station is, of course, not entirely satisfactory, nevertheless, no part of the ordinary work has been suspended and some new lines of activity have opened out. The grant-in-aid of the research work, made by the Development Commissioners, has been continued and this provides for the work being done by Messrs. Bruce and Chadwick. Very welcome has been a grant from the University of Liverpool of £300 a year, on the whole, then, we have been enabled to "carry on," although there is always some anxiety as to the future.

RESEARCH WORK.

Several papers dealing with research work carried on wholly, or partially, at the station have been published since the date of publishing the last Report, and these are :—

H. C. Chadwick, A.L.S.

L.M.B.C. Memoir, No. 25, "Asterias," pp. 63. 9 plates.
(University Press of Liverpool, 1923).

W. C. Smith.

Special Publications, No. 1. "A History of the Irish Sea Herring Fisheries in the eighteenth and nineteenth centuries." pp. 49.

(University Press of Liverpool, 1923.)

E. C. Herdman, M.Sc. (Miss).

"Notes on Dinoflagellates," pp. 6 (in the Appendix to this Report, 1923).

W. J. Dakin, D.Sc.

"The Water Vascular System of Echinoderms," pp. 4
(in the Appendix to this Report, 1923).

Margery Knight, D.Sc.

"Studies in the Ectocarpaceae. I. The Life-History and Cytology of *Pyliella Litoralis*, Kjellm. pp. 18. 6 plates.

(*Transactions Royal Society of Edinburgh*. Vol. LIII,
Pt. II, No. 17, 1923.)

Work which is completed and which is in course of publication is as follows :—

J. Johnstone, A. Scott, and W. C. Smith.

- “ I. The Cod Fishery of the Irish Sea ” ; “ II. The Cod as a Food Fish ” ; “ III. Parasites and Diseases of the Cod.”

(Work done under the scheme of Directed Research of the Ministry of Agriculture and Fisheries, and received for publication by the Ministry.)

J. Johnstone, A. Scott, and H. C. Chadwick.

- “ The Marine Plankton, with Special Reference to the Investigations carried on at Port Erin during the years 1907-1914.” About 200 pages, 25 plates and 40 tables.

(In the Press—University Press of Liverpool.)

Paper communicated to the Zoological Society of London :

H. C. Chadwick.

- “ Abnormal Forms of Echini.”

RESEARCH WORK IN PROGRESS.

The investigations made by Mr. J. R. Bruce during the year 1923 are described on pp. 16 and 19 in this Report. They deal with lines of research suggested by the fishery and plankton work carried on at Port Erin in the past, and have as their general idea the study of organic production in the sea. At each step new problems suggest themselves, and some of these will necessitate highly specialised chemical investigation. Advance along the lines of work that are anticipated now requires co-operation and the facilities of the Biological side of the Station and the Bio-chemical Laboratory are offered to any investigator that cares to join us in this work. Some purely routine research in connection with the conditions of marine metabolism are necessary at this stage—for instance, simple, complete quantitative analyses of the entire bodies of

marine animals and plants. It is extraordinary that only in a few exceptional cases do we know what is the chemical composition of such organisms, that is, the percentages of water, and of the elements, C, N, H, with the halogens and heavy metals.

[Here I would invite particular attention to a paper by M. W. J. Vernadsky: "La Composition Chimique de la matière vivante et la chimie de l'écorce terrestre," in *Revue Générale des Sciences*, 30 January, 1923, pp. 42-51. An abridged translation of a paper sent to me by M. Vernadsky is published as an appendix to this Report. In it the author points out that there is urgent need for co-operation between marine biological, agricultural and geological institutes for exhaustive routine, quantitative analyses of the bodies of organisms both marine, fresh water and land forms. This is work in which marine biological stations might well co-operate. M. Vernadsky also makes a powerful appeal for the establishment of a "Bio-geochemical Institute" to direct and co-ordinate such work.]

The work done by Dr. Margery Knight on the life-histories of Marine Algae is being continued as actively as conditions allow, and it is hoped that an opportunity for its further development may arise. The investigations are closely related to the bio-chemical work which is referred to in Mr. Bruce's report.

Professor Dakin's investigations on the rate of oxygen-consumption by developing plaice ova also make contact with the bio-chemical research which Mr. Bruce deals with in his report. Professor Dakin has extended his research to gold-fish, and has obtained results which are highly interesting in connection with Pütter's well-known theory of nutrition in aquatic animals. These results (with those relating to the Port Erin plaice egg work) are being published elsewhere.

Mr. H. C. Chadwick is engaged on a description of the

morphology and life-history of *Ophiura*, which will be published in due course, as an "L.M.B.C. Memoir." He is also making out details as to the occurrence of various invertebrate larvae in the local plankton.

FISHERY INVESTIGATIONS.

Mr. W. Birtwistle spent several months, during the summer and autumn of 1923 at Peel and Port Erin, working on the biology of the Herring. (This was work carried on under the Directed Research Scheme of the Ministry of Agriculture and Fisheries). Large series of measurements of fish landed were obtained, and an extensive collection of scales was made. Simular work was done at Port Erin by Mr. W. C. Smith.

Reports by Mr. J. R. Bruce and Mr. W. C. Smith on the research work and administration of the Station are given in the following pages.

CURATOR'S REPORT.

The facilities offered by the Station attracted 85 workers who made 88 separate visits during the year. As in the past, the majority were undergraduate students from Zoological and Botanical Departments, and represented the Universities of Cambridge, Liverpool, Wales (Cardiff, Aberystwith and Bangor) and the University College of Reading: Onndle School and the Holt Secondary School, Liverpool, also sent students. In addition, the Biological and Bio-chemical laboratories have been occupied by research workers from various Institutions.

In the Bio-Chemical laboratory, Professor W. J. Dakin extended his observations on the oxygen requirements of the developing eggs and larvae of the plaice, in continuation of his work on marine metabolic problems, and Mr. W. M. Speight carried out some observations on the hydrogen ion concentration of rock pools.

Dr. Margery Knight has completed her work on the life-history of the brown Alga *Pylaiella*, and has published a Memoir upon her results in the *Proceedings of the Royal Society of Edinburgh*. Dr. Harald Kylin, of the Botanical Institute of Lund, Sweden, collected Marine Algae and made a comparative study of the red pigment Phycoerythrin, in various genera; Professor R. Ruggles Gates also made a collection of the local Marine Algae.

Mrs. Bisbee carried out some experiments on the temperature co-efficient of respiration in plaice, and Mr. S. Burfield obtained material for his work on *Sagitta*; Miss I. A. F. Hilton examined the parasites of various marine invertebrates.

In connection with her forthcoming publication, Dr. Marie Lebour collected and examined specimens of the local Peridiniæ for comparison with the more southern forms occurring in the English Channel; and Miss E. C. Herdman continued her observations on the occurrence and life-history of the Dinoflagellate *Amphidinium*, and has obtained material and data for her projected Memoir on *Botryllus*.

Mr. G. E. Hutchinson was investigating the action of internal secretions on the chromophores of young cephalopods, and Dr. Francis Ward made use of the large photographic tank which he erected at the Station some years ago, and obtained a good photographic series of fishes and other marine animals.

Professor Sir William Herdman has continued his plankton investigation and also carried on dredging operations from the "Redwing," introducing an otter trawl for the work, with excellent results.

During the year Mr. W. Birtwistle has made numerous visits in connection with his study of the local herring shoals.

Professor Newstead discovered a new species of coccid on the bladder campion which was growing on rocks near the Biological Station.

The Fish Hatchery.

The commencement of the plaice spawning period of 1923 was delayed and the first eggs did not appear in the pond until the 8th March, about a fortnight later than the normal and three weeks behind the opening of the season in 1922. Spawning continued until the first week in May, and the number of eggs collected and larvae set free is shown in the table appended.

Week ending			Mean Temp. of pond, F.	Eggs collected	Fertilised eggs (and larvae) set free
March	10th	...	43°·7	34,650	...
„	17th	...	43°·1	134,400	...
„	24th	...	42°·4	567,000	...
„	31st	...	45°·4	657,300	71,400
April	7th	...	46°·5	894,600	343,350
„	14th	...	45°·3	550,200	773,350
„	21st	...	46°·2	270,900	788,550
„	28th	...	47°·4	138,900	399,000
May	5th	...	51°·7	132,300	444,150
„	12th	...	52°·6	...	212,100
Totals			...	3,680,250	3,031,900

On the 21st November, 1922, the stock consisted of 57 new fish caught during October and November, and 41 survivors from the previous spawning season. In addition, 26 plaice which were not in very good condition, were segregated and put into the west pond.

The fall of rock which occurred in February, 1922, necessitated much work of reconstruction to the ponds during the year, and it was not possible adequately to replenish the stock, therefore the number of spawners this season was small. Whether the newness of the concrete has had any appreciable effect on the fish is difficult to judge, but the yield of eggs per fish this year is much below that obtained in 1922 which, however, was an exceptionally good season and much in

advance of the two preceding years. The fact that new stock was perforce sparingly introduced had some effect on the productivity for we have found that plaice which are kept for more than one season are not so productive as fish but newly removed from their natural surroundings. Almost half the stock this year consisted of fish which had spawned in the ponds during the previous season and, under the circumstances, a total of 3,031,900 fertilised eggs and larvae set free, is good.

No fertilised eggs were taken from the west pond which contained the 26 fish in poor condition, although two young plaice, 34 and 35 mm. in length, were found when the pond was emptied on the 12th July. Only six spawners remained alive in this pond on that date, one male and five females, and one of the females had eggs still undischarged from the ovary. These six fish were marked, and liberated half a mile north-west of Bradda Head, and one was recaptured three days later in a fixed herring net anchored in Port Erin Bay.

Particulars of plaice found in west pond on the 12th July.

Size	Sex	Condition of gonads
38	♂	Spent
40		Spent
43		Almost full (bound)
48		Some eggs still in ovary
48		Spent
36		Spent

When the east pond was emptied, on the 26th July, 44 live plaice were found, also two dead specimens and 10 skeletons—all that remained of 101 plaice which were counted in the pond on the 21st November, 1922. This represents a very heavy mortality which is probably accounted for, to some extent, by the large proportion of old stock in the pond. Six of the females had not discharged all their eggs, and one

fish was quite full. Particulars of the plaice found in the pond on the 26th July follow.

Cm. size	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	Total
Males—																					
Dead													1								1
Rejected ...							1														1
Retained ..	1	1			1			2		1	1		1		1						9
Total Males ...	1	1			1		1	2		1	1		2		1						11
Females—																					
Dead											1										1
Rejected ...						1	1			1		1	2			1				1	8
Retained ..							2		3	2	5	3	2	2	1		2	1	1	2	26
Total Females ..						1	3		3	3	6	4	4	2	1	1	2	1	1	3	35
Total ♂ and ♀ combined ...	1	1			1	1	4	2	3	4	7	4	6	2	2	1	2	1	1	3	46

Females which had not discharged all their eggs.

Size (cm.)	State of gonads.
37	about half-full.
39	full.
41	about half-full.
42	full.
44	about half-full.
50	about half-full.

A few of the fish were rejected on account of their poor condition, and were set aside for gonad and otolith examination, which resulted as follows :—

Size	Sex	Condition of gonads	Age Group
37	♂	Mature ...	V
36	♂	Immature ...	V
37	♂	Immature ...	IV
40	♂	Immature ...	VI
42	♂	Mature ...	V
43	♂	V
43	♂	VIII
46	♂	VII
50	♂	about IX

Young fish of this year's hatching were found in good quantities and transferred to the tanks. A few were measured and their otoliths examined, the following table showing the size, and it represents generally the run of the young fish taken from the pond.

Mm. size		34	35	40	41	45	46	49	51	56	Total	
No. of fish	1	2	1	2	2	1	2	1	1	13

A diseased female plaice was taken from one of the Aquarium tanks on July 11th, and the ovaries were found to be full of eggs which appeared to be mature: the genital opening was closed. The fish was four years old and 38 cm. in length.

Lobster Culture.

In the months of July and August, 30 berried lobsters were obtained from local fishermen and placed in the pond. They yielded 25,220 larvae, an average of 841 per lobster, which can be described as a fair result.

It is essential that the eggs be well advanced in development when the lobster is taken from the sea or poor results accrue, and this entails the risk of losing some of the ripe eggs when handling the animals. A few of the lobsters obtained had lost a proportion of their eggs before reaching the pond, so the figures given must be taken as a decidedly minimum reflection of the productivity.

Of the total larvae taken from the pond, 1,270 were put into the rearing jars and dishes and fed exclusively on plankton: 291 of them reached the lobsterling stage and were then set free in the sea. The remainder, 23,950, were liberated in their first stage of development, at suitable positions off the coast. Larvae were first collected on the 5th July, and the hatching period terminated about the 22nd August.

An unsuccessful attempt was made to rear young lobsters in carboys filled with sea-water. A constant stream of air was passed into the water to aerate it, and also set up some degree of motion with the object of keeping the young lobsters apart, for their strong cannibalistic instincts at this stage constitute one of the chief obstacles to success in any method of lobster culture. Four carboys were used and 50 larvae were put into each of them on the 4th July. Three weeks later a stock was taken and it was found that only three larvae, in their third stage, remained alive. Thinking that the air supply might be insufficient or that the number placed in each carboy was too great, it was decided to concentrate the full pressure of air into two carboys and place 30 larvae in each. The result was, that at the end of four weeks, only two lobsterlings were found. After this, one carboy received the full air current and 20 larvae were introduced. At the expiration of five weeks it was examined, when the remains of two lobsterlings were found. During each experiment the larvae were fed, almost daily on plankton.

Until a more successful method is devised, rearing jars will remain the most effective apparatus, and, if more jars could be provided and the means of collecting plankton food improved, it would be possible to increase the number of lobsterlings set free in the sea.

The Aquarium.

Inclement weather during the past summer adversely affected the Manx holiday season, and this is reflected in the total number of visitors to the Aquarium for the year, which is 24,128 against 28,859 last year.

The tanks were well stocked and the display of larval lobsters in various stages of development was a source of considerable interest to the visitors.

Early in the season the fourth edition of the "Guide to

the Aquarium " was exhausted and no further copies could be obtained: as a consequence the total number disposed of this year only amounted to 68. Annual Reports, L.M.B.C. Memoirs, Maps, etc., were sold to the public in fair numbers.

List of Workers, 1923.

March 19 to	March 20	Mr. W. C. Smith, Fisheries Lab., Liverpool.	Herring Investigations, etc.
.. 21 ..	April 2	Miss E. G. Torrance, Botany School, Cambridge.	Marine Algæ.
.. ..	..	Miss S. M. Manton, Botany School, Cambridge.	Marine Algæ.
.. ..	..	Miss J. S. Willis, Botany School, Cambridge.	Marine Algæ.
.. ..	..	Mr. A. W. Exell, Botany School, Cambridge.	Marine Algæ.
.. ..	..	Mr. T. A. Burnet-Clark, Botany School, Cambridge.	Marine Algæ.
.. ..	..	Mr. F. C. Deighton, Botany School, Cambridge.	Marine Algæ.
.. ..	..	Mr. T. Harris, Botany School, Cambridge.	Marine Algæ.
.. ..	..	Mr. H. Hamshaw Thomas, Botany School, Cambridge.	Marine Algæ.
.. ..	..	Mr. S. M. Wadham, Botany School, Cambridge.	Marine Algæ.
.. 22 to	March 28	Miss M. Knight, Liverpool U.	Algæ (Ectocarpaceæ).
.. 23 ..	.. 29	Miss K. M. Drew, Manchester U.	Marine Algæ.
.. 23 ..	April 4	Professor E. J. Cole, Univ. Coll., Reading.	Gen. Marine Zoology.
.. ..	..	Dr. Nellie B. Eales, Univ. Coll., Reading.	Gen. Marine Zoology.
.. ..	..	Mr. T. H. Taylor, Univ. Coll., Reading.	Gen. Marine Zoology.
.. ..	..	Mr. Palmer, Univ. Coll., Reading.	Gen. Marine Zoology.
.. ..	..	Miss M. Brown, Univ. Coll., Reading.	Gen. Marine Zoology.
.. ..	..	Miss A. Heap, Univ. Coll., Reading.	Gen. Marine Zoology.
.. 24 ..	.. 5	Professor W. M. Tattersall, Univ. Coll., Cardiff.	Gen. Marine Zoology.
.. ..	..	Miss E. M. Sheppard, Univ. Coll., Cardiff.	Gen. Marine Zoology.
.. ..	..	Miss C. M. Griffiths, Univ. Coll., Cardiff.	Gen. Marine Zoology.
.. ..	..	Miss E. Evans, Univ. Coll., Cardiff.	Gen. Marine Zoology.
.. ..	..	Miss M. Edworthy, Univ. Coll., Cardiff.	Gen. Marine Zoology.
.. ..	..	Miss M. Mann, Univ. Coll., Cardiff.	Gen. Marine Zoology.
.. 24 ..	.. 28	Professor W. J. Dakin, Liverpool U.	Marine Metabolic Problems.

Mar. 29 to	April 25	Professor Sir W. A. Herdman, Liverpool U.	Plankton and General.
" "	"	Miss E. C. Herdman, Liverpool U.	Ascidians (Botryllus).
" 29 "	" 9	Miss M. Allen, Liverpool U.	Cataloguing Library, etc.
" "	" 28	Miss M. S. C. Fordham, Liverpool U.	
" 30 "	" 4	Professor J. Johnstone (Director), Liverpool U.	Official.
April 3 "	" 12	Mr. S. T. Burtfield, Liverpool U.	Sagitta.
" 6 "	" 15	Miss O. R. Bangham, Holt Sec. School, Liverpool.	Gen. Marine Biology.
" 6 "	" 15	Mr. Geo. Cliffe, Holt Sec. School, Liverpool.	Gen. Marine Biology.
" 6 "	" 15	Mr. Geo. Williams, Holt Sec. School, Liverpool.	Gen. Marine Biology.
" 6 "	" 23	Mrs. Bisbee, Liverpool U.	Temperature Co-efficient of Respiration in Plaice.
" 7 "	" 29	Miss E. Angel, Liverpool U.	
" 7 "	" 29	Miss J. A. F. Hilton, Liverpool U.	Parasites of Buccinum.
" 7 "	" 28	Miss E. Lowe, Liverpool U.	Gen. Marine Zoology.
" 9 "	" 15	Mr. E. W. Shann, Oundle School.	Gen. Marine Biology.
" "	"	Mr. E. E. Watkins, Univ. Coll. Aberystwyth.	Gen. Marine Biology.
" "	"	Mr. W. M. Speight, Univ. Coll., Aberystwyth.	Chemical Hydrography.
" "	"	Mr. P. A. Little, Univ. Coll., Aberystwyth.	Parasitology.
" "	"	Mr. S. B. Thomas, Univ. Coll., Aberystwyth.	Gen. Marine Biology.
" "	"	Mr. P. L. Emery, Univ. Coll., Aberystwyth.	Gen. Marine Biology.
" "	"	Mr. Varugis, Univ. Coll., Aberystwyth.	Gen. Marine Biology.
" "	"	Miss B. Fox, Univ. Coll., Aberystwyth.	Gen. Marine Biology.
" "	"	Miss L. Beanland, Univ. Coll., Aberystwyth.	Gen. Marine Biology.
" "	"	Miss B. Lloyd, Univ. Coll., Aberystwyth.	Gen. Marine Biology.
" 9 "	" 21	Miss M. Spencer, Avenue Training Coll., Southampton.	Marine Algæ.
" 10 "	" 15	Mr. W. J. Batt, (Lab. Assistant), Oundle School.	Gen. Marine Biology.
" "	"	Mr. J. S. Blair, Oundle School.	Gen. Marine Biology.
" "	"	Mr. V. Christophers, Oundle School.	Gen. Marine Biology.
" "	"	Mr. J. K. Flower, Oundle School.	Gen. Marine Biology.
" "	"	Mr. J. L. Lovibond, Oundle School.	Gen. Marine Biology.
" "	"	Mr. J. A. Orme, Oundle School.	Gen. Marine Biology.
" 13 "	" 27	Miss L. Thorpe, Univ. Coll., Bangor.	Gen. Marine Zoology.
" "	"	Miss M. G. Owen, Univ. Coll., Bangor.	Gen. Marine Zoology.

April 16 to	April 28	Miss D. M. Schulthess, Liverpool U.	Gen. Marine Zoology.
" "	"	Miss E. B. Whiteside, Liverpool U.	Gen. Marine Zoology.
" "	"	Miss M. L. Jones, Liverpool U.	Gen. Marine Zoology.
" "	"	Miss L. Law, Liverpool U.	Gen. Marine Zoology.
" "	"	Miss A. Whitaker, Liverpool U.	Gen. Marine Zoology.
" "	"	Miss W. R. Frost, Liverpool U.	Gen. Marine Zoology.
" "	"	Miss E. J. Rutherford, Liverpool U.	Gen. Marine Zoology.
" 16 "	" 21	Miss James, Liverpool U.	Gen. Marine Zoology.
" 16 "	" 21	Miss Peace, Liverpool U.	Gen. Marine Zoology.
" 16 "	" 28	Miss M. Routledge, Liverpool U.	Gen. Marine Zoology.
" "	"	Miss M. Veale, Liverpool U.	Gen. Marine Zoology.
" "	"	Miss A. Foxcroft, Liverpool U.	Gen. Marine Zoology.
" "	"	Miss E. Metcalfe, Liverpool U.	Gen. Marine Zoology.
" "	"	Miss C. Wagland, Liverpool U.	Gen. Marine Zoology.
" "	"	Miss N. Miller, Liverpool U.	Gen. Marine Zoology.
" "	"	Miss N. Considine, Liverpool U.	Gen. Marine Zoology.
" "	"	Mr. H. Lister, Liverpool U.	Gen. Marine Zoology.
" "	"	Mr. T. R. Scott, Liverpool U.	Gen. Marine Zoology.
" 17 "	" 25	Miss E. N. Staidler, Liverpool U.	Gen. Marine Zoology.
" 20 "	" 29	Miss Wilson, Liverpool U.	Marine Algæ.
June 3 "	Oct. 1	Mr. W. Birtwistle, Liverpool U.	Herring Studies.
" 9 "	" 30	Dr. Francis Ward.	Nature Photography.
July 4 "	July 6	Miss Fry, Liverpool U.	Marine Algæ.
" 4 "	Aug. 30	Dr. Margery Knight, Liverpool U.	Marine Algæ.
" 6 "	July 31	Dr. Harold Kylin, Lund U., Sweden.	Marine Algæ.
" 28 "	Sept. 30	Professor Sir Wm. Herdman, Liverpool U.	Plankton and General.
Aug. 9 "	" 30	Miss E. C. Herdman, Liverpool U.	Ascidians.
" 7 "	Aug. 18	Professor R. Newstead, Liverpool U.	Insects, etc.
Sept. 20 "	" 30	Dr. Marie Lebour, Plymouth.	Peridinians.
" 20 "	" 23	Professor R. Ruggles Gates, King's Coll., London.	Marine Algæ.
" 24 "	" 27	Mr. G. E. Hutchinson, Cambridge U.	Cephalopods.

W. C. SMITH.

BIO-CHEMICAL LABORATORY.

Since June, 1923, when the appointment of Mr. W. C. Smith, as administrative Curator, afforded me the opportunity for continuous scientific work, two main lines of research have been pursued.

The first consists of a study of the general bionomics and metabolism of the Herring, regarded from a bio-chemical point of view, and is a continuation and extension of work carried out for a number of years, by Professor Johnstone and co-workers, for the Lancashire and Western Sea-Fisheries Committee.

Variations in the chemical composition of the tissues, in relation to age, sex, and sexual maturity, are being studied, and a report upon the analyses of some twenty samples, comprising about 120 fish, selected from the Peel (I.O.M.) landings, at various dates throughout the season, is in course of preparation.

Mr. W. Birtwistle, of the Oceanography Department, has very kindly co-operated by obtaining these samples, and by determining the age and condition of the fish. In addition, the results of some tissue-analyses carried out by Mr. John Secker, B.Sc., at the Millport Marine Station, and kindly placed in my hands by Mr. R. Ehnirst, will be utilised in the preparation of the paper.

It is hoped, at a later date, to amplify the gross analytical statement of the main food-substances, by determining the fatty acids present in the oil, and possibly also, the amino-acid content of the muscle-substance, at various stages in the life of the fish.

Data of this kind would serve to give precise expression to a fact of popular experience—the wide difference in flavour and quality between herrings caught at different seasons and on different fishing-grounds.

The general scheme in view would involve, ultimately, an investigation of the external and purely physical conditions—light, temperature, salinity, hydrogen-ion concentration, etc.—associated with the various phases of the life-cycle of the herring.

Regarded together with the very full planktonic and biometric information already established, such data should make possible some explanation of the phenomena of shoaling, spawning, and migration, and afford definite indication of the time, area and conditions, in which the fish may be found commercially in its successive stages.

In this direction, a number of water-samples taken in

the vicinity of the herring-shoals off the west coast of the Isle of Man have been examined, but this attempt was quite preliminary, and conditions proved unfavourable for obtaining satisfactory samples.

It seems hardly possible to develop this aspect of the work under present conditions, since the lack of a sea-going vessel quite prevents the close chemical and hydrographical observations which it involves.

The second piece of work is directed towards elucidating the chemical conditions of life in and upon coastal sands.

The great abundance and variety of animal and plant life—molluscs, annelids, dinoflagellates, diatoms, and other forms—inhabiting the sandy shore, denotes a rich abundance of food-material and a peculiarly effective metabolic nexus as between the different forms. Tidal ebb and flow, and the resulting periodic activity of shore-life, involves much more than mere alternation of exposure and immersion. Each flood-tide brings to the shore new supplies of nitrates, nitrites, oxygen, and other essential materials, and permits new reaction-equilibria to be set up. Each ebb carries away waste products, exposes the shore to insolation and temperature-changes, and allows rain and streams to dilute the sea-water remaining between the sand-grains.

Such are a few of the littoral conditions it is proposed to study in detail.

Work already carried out has had for its immediate object the explanation of the remarkable vertical migrations of the dinoflagellate *Amphidinium*, and its alternation in abundance with Diatoms, on the same patch of sand, as noted and reported upon by Miss E. C. Herdman, in recent volumes of the Liverpool Biological Society's Transactions.

The assimilatory activity of this organism has been shown to depend upon the salinity of the interstitial water, and has its optimum at about one-quarter the normal salinity of sea-

water. There is some evidence, also, to show that, while a diurnal alternation obtains between a holophytic and a holozoic type of metabolism, the former, at any rate normally, preponderates in the nett result.

A report upon this work is in progress.

To establish the relation, if such exists, between the content of organic matter in shore-sand, and the abundance of living animals therein, a survey of Port Erin beach is in progress, in which samples of the sand-layers at various depths are being collected for analysis.

The distribution of the well-known "black layer" in the sand is being observed, and it has been found possible to produce an identical appearance in sand containing added organic matter, kept in the laboratory. The hydrogen-ion concentration of the successive strata in such preparations has been found to agree exactly with that observed at the corresponding depths and colour-zones, in situ upon the shore.

Work is about to commence upon the gaseous exchanges of certain common shore-animals, notably the Mussel, and it is hoped by this means to throw light upon the nature and extent of their food-intake and utilisation.

It will be seen that a large programme of work is contemplated.

It cannot all be done single-handed, and the co-operation of as many workers as possible is earnestly to be desired.

The bio-chemical laboratory at Port Erin offers special facilities to workers in this field, especially to those who are able to devote an extended period to the work.

Full particulars will be furnished on application to the Director.

J. R. BRUCE.

THE EDWARD FORBES EXHIBITION.

The Exhibitioner for the year 1923 was Miss Laura Thorpe, B.Sc., who worked on the morphology of the Alcyonaria. Miss Thorpe also rendered valuable assistance in the conduct of the Easter Zoology Class at the station.

(See pp. 52-53 for the Regulations with regard to this Exhibition).

“ L.M.B.C. MEMOIRS.”

Although the Liverpool Marine Biology Committee has now been dissolved, it is thought well to retain the former title for this series of publications. They have become well known in laboratories and are referred to in literature as the “ L.M.B.C. Memoirs,” and it would only lead to confusion to change the title, although they are no longer published by a Committee but by the Oceanography department of the University.

Since the last report was published, the Memoir on *ASTERIAS* has been issued to the public. Miss E. L. Gleave, M.Sc., has nearly completed her Memoir on *DORIS*, the Sea-lemon ; Mr. Burfield, is writing the Memoir on *SAGITTA* ; Mrs. Bisbee has made further progress with *TUBULARIA* and Miss E. C. Herdman is far advanced with *BOTRYLLUS*.

The following shows a list of the Memoirs already published :

- I. *ASCIDIA*, W. A. Herdman, 60 pp., 5 Pls.
- II. *CARDIUM*, J. Johnstone, 92 pp., 7 Pls.
- III. *ECHINUS*, H. C. Chadwick, 36 pp., 5 Pls.
- IV. *CODIUM*, R. J. H. Gibson and H. Auld, 3 Pls.
- V. *ALCYONIUM*, S. J. Hickson, 30 pp., 3 Pls.
- VI. *LEPEOPHTHEIRUS* AND *LERNÆA*, A. Scott, 5 Pls.
- VII. *LINEUS*, R. C. Punnett, 40 pp., 4 Pls.
- VIII. *PLAICE*, F. J. Cole and J. Johnstone, 11 Pls.
- IX. *CHONDRUS*, O. V. Darbishire, 50 pp., 7 Pls.
- X. *PATELLA*, J. R. A. Davis and H. J. Fleure, 4 Pls.
- XI. *ARENICOLA*, J. H. Ashworth, 126 pp., 8 Pls.
- XII. *GAMMARUS*, M. Cussans, 55 pp., 4 Pls.

- XIII. ANURIDA, A. D. Imms, 107 pp., 8 Pls.
- XIV. LIGIA, C. G. Hewitt, 45 pp., 4 Pls.
- XV. ANTEDON, H. C. Chadwick, 55 pp., 7 Pls.
- XVI. CANCER, J. Pearson, 217 pp., 13 Pls.
- XVII. PECTEN, W. J. Dakin, 144 pp., 9 Pls.
- XVIII. ELEDONE, A. Isgrove, 113 pp., 10 Pls.
- XIX. POLYCHAET LARVÆ, F. H. Gravely, 87 pp., 4 Pls.
- XX. BUCCINUM, W. J. Dakin, 123 pp., 8 Pls.
- XXI. EUPAGURUS, H. G. Jackson, 88 pp., 6 Pls.
- XXII. ECHINODERM LARVÆ, H. C. Chadwick, 40 pp., 9 Pls.
- XXIII. TUBIFEX, G. C. Dixon, 100 pp., 7 Pls.
- XXIV. APLYSIA, Nellie Eales, 84 pp., 7 Pls.
- XXV. ASTERIAS, H. C. Chadwick, 63 pp., 9 Pls.

As the result of a slight fire in the Zoology Department of the University, a portion of the stock of L.M.B.C. Memoirs has been partially destroyed. There are a certain number of damaged copies of some of the Memoirs which are stained or singed externally, but are still quite usable, and are suitable for laboratory work. It has been decided to offer these at prices ranging according to the condition from one-half to one-fourth of the published prices, as follows:—
 Memoir I., Ascidia, 6d. to 9d. : VI., Lepeophtheirus and Lernæa, 6d. to 1s. : VII., Lineus, 6d. to 1s. : XIII., Anurida, 1s. to 2s. : XIV., Ligia, 6d. to 1s. : XV., Antedon, 6d. to 1s. 3d.

Memoirs should be ordered from the University Press, Ashton Street, Liverpool.

Appended to this Report are:—

- (A) The Laboratory Regulations—with Memoranda for the use of students, and the Regulations in regard to the “Edward Forbes Exhibition” at the University of Liverpool;
- (B) The Financial Statement, List of Subscribers, and Balance Sheet for the year.
- (C) Several original Memoirs (see Contents).

APPENDIX A

LIVERPOOL MARINE BIOLOGICAL STATION

AT
PORT ERIN.

GENERAL REGULATIONS.

I.—This Biological Station is under the control of the Oceanography department of the University of Liverpool, and the Director of the Laboratory is the Professor of Oceanography.

II.—In the absence of the Director, the Station is under the temporary control of the Curator (Mr. W. C. Smith), who will keep the keys, and will decide, in the event of any difficulty, which places are to be occupied by workers, and how the tanks, boats, collecting apparatus, etc., are to be employed.

III.—The Curator will be ready at all reasonable hours and within reasonable limits to give assistance to workers at the Station, and to do his best to supply them with material for their investigations.

IV.—Visitors will be admitted, on payment of a small specified charge, at fixed hours, to see the Aquarium and Museum adjoining the Station. Occasional public lectures are given in the Institution by members of the staff.

V.—Those who are entitled to work in the Station, when there is room, and after formal application to the Director, are :—(1) Annual Subscribers of one guinea or upwards to the funds (each guinea subscribed entitling to the use of a work place for three weeks), and (2) others who are not annual subscribers, but who pay the University 10s. per week for the accommodation and privileges. Institutions, such as Universities and Museums, may become subscribers in order that a work place may be at the disposal of their students or staff for a

certain period annually ; a subscription of two guineas will secure a work place for six weeks in the year, a subscription of five guineas for four months, and a subscription of £10 for the whole year.

VI.—Each worker is entitled to a work place opposite a window in the Laboratory, and may make use of the microscopes and other apparatus, and of the boats, dredges, tow-nets, &c., so far as is compatible with the claims of other workers, and with the routine work of the Station.

VII.—Each worker will be allowed to use one pint of methylated spirit per week free. Any further amount required must be paid for. All dishes, jars, bottles, tubes, and other glass may be used freely, but must not be taken away from the Laboratory. Workers desirous of making, preserving, or taking away collections of marine animals and plants, can make special arrangements with the Director in regard to bottles and preservatives. Although workers in the Station are free to make their own collections at Port Erin, it must be clearly understood that (as in other Biological Stations) no specimens must be taken for such purposes from the Laboratory stock, nor from the Aquarium tanks, nor from the steam-boat dredging expeditions, as these specimens are the property of the Institution. The specimens in the Laboratory stock are preserved for sale, the animals in the tanks are for the instruction of visitors to the Aquarium, and as all the expenses of steam-boat dredging expeditions are defrayed from the funds, the specimens obtained on these occasions must be retained (*a*) for the use of the specialists working at the Fauna of Liverpool Bay, (*b*) to replenish the tanks, and (*c*) to add to the stock of duplicate animals for sale from the Laboratory.

VIII.—Each worker at the Station is expected to prepare a short report upon his work—not necessarily for publication—to be forwarded to the Director before the end of the year for notice, if desirable, in the Annual Report.

IX.—All subscriptions, payments, and other communications relating to finance, should be sent to the Accountant, the University of Liverpool. Applications for permission to work at the Station, or for specimens, or any communications in regard to the scientific work should be made to the Director, Department of Oceanography, University, Liverpool.

MEMORANDA FOR STUDENTS AND OTHERS WORKING AT THE PORT ERIN BIOLOGICAL STATION.

Post-graduate students and others carrying on research will be accommodated in the small work-rooms of the ground floor laboratory and in those on the upper floor of the new research wing. Some of these little rooms have space for two persons who are working together, but researchers who require more space for apparatus or experiments will, so far as the accommodation allows, be given rooms to themselves.

Undergraduate students working as members of a class will occupy the large laboratory on the upper floor or the front museum gallery, and it is very desirable that these students should keep to regular hours of work. As a rule, it is not expected that they should devote the whole of each day to work in the laboratory, but should rather, when tides are suitable, spend a portion at least of either forenoon or afternoon on the sea-shore collecting and observing.

Occasional collecting expeditions are arranged under guidance either on the sea-shore or out at sea, and all undergraduate workers should make a point of taking part in these.

It is desirable that students should also occasionally take plankton gatherings in the bay for examination in the living state, and boats are provided for this purpose at the expense of the Biological Station to a reasonable extent. Students desiring to obtain a boat for such a purpose must apply to the Curator

at the Laboratory for a boat voucher. Boats for pleasure trips are not supplied by the Biological Station, but must be provided by those who desire them at their own expense.

Students requiring any apparatus, glass-ware or chemicals from the store-room must apply to the Curator. Although a few microscopes are kept at the Biological Station, these are mainly required for the use of the staff or for general demonstration purposes. Students are therefore strongly advised, especially during University vacations, not to rely upon being able to obtain a suitable microscope, but ought if possible to bring their own instruments.

Students are advised to provide themselves upon arrival with the "Guide to the Aquarium" (price 6d.), and should each also buy a copy of the set of Local Maps (price 2d.) upon which to insert their faunistic records and other notes.

Occasional evening meetings in the Biological Station for lecture and demonstration purposes will be arranged from time to time. Apart from these, it is generally not advisable that students should come back to work in the laboratory in the evening; and in all cases all lights will be put out and doors locked at 10 p.m. When the institution is closed, the key can be obtained, by those who have a valid reason for entering the building, only on personal application to the Curator.

REGULATIONS OF THE EDWARD FORBES EXHIBITION.

[Extracted from the *Calendar* of the University of Liverpool
for the Session 1920-21, p. 427.]

“ EDWARD FORBES EXHIBITION.

“ Founded in the year 1915 by Professor W. A. Herdman, D.Sc., F.R.S., to commemorate the late Edward Forbes, the eminent Manx Naturalist (1815-1854), Professor of Natural History in the University of Edinburgh, and a pioneer in Oceanographical research.

The Regulations are as follows :—

(1) The interest of the capital, £100, shall be applied to establish an Exhibition which shall be awarded annually.

(2) The Exhibitioner shall be a post-graduate student of the University of Liverpool, or, in default of such, a post-graduate student of another University, qualified and willing to carry on researches in the Manx seas at the Liverpool Marine Biological Station at Port Erin, in continuation of the Marine Biological work in which Edward Forbes was a pioneer.

(3) Candidates must apply in writing to the Registrar, on or before 1st February.

(4) Nomination to the Exhibition shall be made by the Faculty of Science on the recommendation of the Professor of Zoology.

(5) The plan of work proposed by the Exhibitioner shall be subject to the approval of the Professor of Zoology.

(6) Should no award be made in any year, the income shall be either added to the capital of the fund, or shall be applied in such a way as the Council, on the recommendation of the Faculty of Science, may determine.

(7) The Council shall have power to amend the foregoing Regulations, with the consent of the donor, during his lifetime, and afterwards absolutely: provided, however, that the name of Edward Forbes shall always be associated with the Exhibition, and that the capital and interest of the fund shall always be used to promote the study of Marine Biology."

EDWARD FORBES EXHIBITIONERS.

- 1915 Ruth C. Bamber, M.Sc.
- 1916 E. L. Gleave, M.Sc.
- 1917 C. M. P. Stafford, B.Sc.
- 1918 Catherine Mayne, B.Sc.
- 1919 George Frederick Sleggs, B.Sc.
- 1920 Laura Thorpe, B.Sc.
- 1921 Maisie Hobbins, B.Sc.
- 1922 O. R. Bangham (Miss), B.Sc.
- 1923 Laura Thorpe, B.Sc.

THE UNIVERSITY OF LIVERPOOL

OCEANOGRAPHY: PORT ERIN ACCOUNT.

LIST OF SUBSCRIPTIONS TO 31st JULY, 1923.

	£	s.	d.
Brunner, Sir J. F. L., 43, Harrington-gardens, London, S.W.	4	4	0
Holt, Miss Sudley, Mossley Hill, Liverpool ...	2	2	0
Halls, W. J., 2, Townfield-road, West Kirby ...	1	1	0
Hutton, J. A., Woodlands, Alderley Edge ...	1	0	0
The Isle of Man Natural History Society, Castle- town, I.O.M.	2	2	0
Mond, R. C.	2	2	0
Muspratt, Dr. E. K., Seaforth Hall, Liverpool ...	5	0	0
Nuttall, F. R. Dixon, Ingleholme, Eccleston Park, Nr. Prescott	2	2	0
Rathbone, Miss M., 48, Norfolk-square, London, W.2	1	0	0
Roberts, Mrs. Isaac, Thomery, S. et M., France ...	1	1	0
Robinson, Miss M. E., Holmfield, Aigburth, L'pool	1	0	0
Salt Union Ltd.	15	15	0
Smith, A. T., 43, Castle-street, Liverpool... ..	2	2	0
Thornely, Miss, Field Head, Out Gate, Ambleside	2	2	0
Toll, J. M., 49, Newsham-drive, Liverpool ...	1	1	0
Watson, A. T., Tapton Crescent-road, Sheffield ...	1	10	0
Whitley, E., 13, Linton-road, Oxford	5	0	0
	£50	4	0

PORT ERIN BIOLOGICAL STATION.

BALANCE SHEET, 31 JULY, 1923

LIABILITIES		£	s.	d.	£	s.	d.
99 Years Lease of Port Erin Biological Station and Fish Hatchery from 5 July, 1920		per contra					
(Vide <i>The Biological Station and Fish Hatchery Transfer Act, 1920</i>)							
Donations:—							
Transfer from Liverpool Marine Biological Committee		909	14	3			
Mr. John Rankin		80	0	0			
					989	14	3
General Account					792	12	2
Memoir Fund					134	0	0
Amount carried forward on Account of Salary					200	0	0
					£2116	6	5

We have examined the above Balance Sheet and certify that it is correct.

HARMLOD BANNER & SON,
Chartered Accountants,
Liverpool, 27 August, 1922.

ASSETS		£	s.	d.	£	s.	d.
99 Years Lease of Port Erin Biological Station and Fish Hatchery from 5 July, 1920	... ..	per contra					
(Vide <i>The Biological Station and Fish Hatchery Transfer Act, 1920</i>)							
Investments at Cost:							
99 Shares in British Workman Public House Company, Limited	... ..	121	5	6			
Funding Loan 4 % 1960-1990, £1135 16s. 7d.	... ..	788	8	9			
Victory Bond 4 % £100	... ..	80	0	0			
					989	14	3
Development Fund	... ..				897	17	0
Cash in Isle of Man Banking Company, Limited, Port Erin Branch	... ..	178	15	2			
Cash in hands of Curator	... ..	50	0	0			
					228	15	2
					£2116	6	5

C. SYDNEY JONES,
Treasurer.

PORT ERIN BIOLOGICAL STATION.

ANNUAL STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE YEAR 1 AUGUST, 1922, TO 31 JULY, 1923.

General Account

PAYMENTS		£	s.	d.	RECEIPTS		£	s.	d.
To Salaries	... ..	100	0	0	By Balance—1 August, 1922	...	310	0	1
" National Insurance (Employer's Contributions)	...	2	3	4	" Interest on Investments	...	43	3	8
" Ordinary Repairs to Premises and Furniture	...	129	4	5	" Subscriptions and Donations	...	50	4	1
" Rates, Taxes, Insurance	...	27	11	2	" Universities and University Colleges for Hire of Work Tables	...	38	7	4
" Carriage and Cartage	...	8	0	0	Port Erin:—				
" Contribution to Superannuation Fund	...	40	0	0	Admissions to Aquarium	...	304	0	3
" Balance—Carried to Balance Sheet	...	752	12	2	Sales of Guides and Postcards	...	17	10	0
					Specimens	...	24	2	11
					Laboratory Fees	...	9	2	0
							354	15	2
					" Grant from I.O.M. Treasury	...	200	0	0
					" Bank Interest	...	3	0	9
					" Rankin Fund for Salary	...	300	0	0
					Less Amount carried forward	...	200	0	0
							100	0	0
							£1039	11	1

Memoir Fund Account

To Expenditure to 31 July, 1923	£41 0 0	By Balance 1 August, 1922	£131 1 2
„ Balance Carried to Balance Sheet	134 0 0	„ Sales and Net Proceeds of Publications	£23 18 10
		„ Donation—E. Whitley, Esq.	10 0 0
			<hr/>
			43 18 10
			<hr/>
			£175 0 0

Development Fund Account

To Salaries	1051 9 6	By Balance 1 August, 1922	£58 4 10
„ Naturalist-in-charge	£400 0 0	„ Grant from Ministry of Agriculture and Fisheries	400 0 0
„ Curator	250 0 0	„ Balance Deficit carried to Balance Sheet	897 17 0
„ Assistant Curator	200 0 0		
„ Fisherman Collector	156 0 0		
„ Boys	15 9 6		
„ Books, Apparatus, Supplies	125 2 0		
„ Boat Hire	12 6 0		
„ Printing, Stationery, Postage	47 8 8		
„ Expenses to Conferences	25 2 11		
„ Fuel, Light and Cleaning	94 12 9		
„ Allocation of Expenditure of Development Fund (Allocation subject to revision by the Commissioners).	<hr/>		
	£1356 1 10		£1356 1 10

APPENDIX C (1)

NOTES ON DINOFLAGELLATES AND OTHER
ORGANISMS CAUSING DISCOLOURATION OF
THE SAND AT PORT ERIN. III.

BY E. CATHERINE HERDMAN, M.Sc.

Zoology Department, University of Liverpool.

(Read October 11th, 1923)

Observations on the shore-living Dinoflagellates at Port Erin have been continued* during 1922 and 1923. On the whole, during the spring and summer of 1923, the Dinoflagellates have been poor in numbers of individuals though rich in species and have caused comparatively little discolouration. Diatoms, on the other hand, have been exceedingly abundant, so much so that on two occasions (August 11th and 13th) their photosynthetic activity was distinctly *audible* as a gentle sizzling to an observer standing upright upon the discoloured area, while the sand was frothy with bubbles of gas, presumably oxygen, given off by them.

The following new species have been observed :—

Glenodinium monense, sp. nov. Body rotund or broadly biconical with bluntly rounded apices and flattened dorso-ventrally to about half its transverse diameter. Total length slightly less than the greatest transdiameter. Epicone and hypocone approximately equal in size, but not set squarely one on the other, the epicone projecting slightly to the right and the hypocone to the left. The girdle runs round the body equatorially, its ends meeting with very slight displacement. The sulcus is extremely short and projects about equally on epi- and hypocone, while the longitudinal flagellum is about three times the length of the body. Two red pusules (?) open into it, one at either end. The large, ovoid nucleus is nearly central in position. Another colourless, highly refractile body is also present. The cytoplasm is yellowish green. The

* See *Trans. L.B.S.* 1912, 1913, 1921 and 1922

whole body is enclosed in a clear and apparently structureless pellicle, which is shed from time to time, splitting in two at the girdle. Length about 25μ .

This species occurred in large numbers from time to time during the summer of 1922, in the inner harbour, close to the concrete steps. It appears to live equally well in salt or fresh water.

Amphidinium fletum, sp. nov. Body flattened dorso-ventrally and slightly twisted, the left posterior region deflected dorsally while the right posterior region is deflected ventrally. Body length about 1.5 transdiameters. Epicone almost equal in width to the greatest transdiameter, its length in the ventral region about 0.26 of the total length. Apex rounded. Hypocone broadly sac-shaped and slightly notched by the sulcus. Girdle almost symmetrical, rising gently to the mid-dorsal region, its two ends meeting without displacement. Transverse flagellum completely encircling the body. Sulcus extending almost from the apex to the antapex. Longitudinal flagellum extending beyond the antapex for a distance nearly as great as the whole length of the body. Nucleus situated in the posterior region. Protoplasm colourless, but full of small yellowish brown granules. Length about 60μ .

This species has occurred from time to time during the last few years, but never in great numbers.

Amphidinium semilunatum, sp. nov. Body flattened from side to side, the length about 1.4 dorso-ventral transdiameters and 3.5 lateral transdiameters. Hypocone sac-shaped, the ventral surface convex, while the dorsal surface is almost flat. Epicone low, but conical with broadly rounded apex—deeper on the left side than on the right. Its greatest depth is on the ventral surface—0.3 of the total body length. The ends of the girdle meet in the mid-ventral region without displacement. It is highest in the right dorsal region. Sulcus deep, extending from the girdle round the antapex to the dorsal side and

causing a notch in the antapex. Longitudinal flagellum arising close to the junction of the sulcus with the girdle. The nucleus is situated in the posteroventral region. The cytoplasm is colourless and of glassy transparency, and usually contains numerous coloured food masses. Length about 50μ .

This species has occurred several times, though never in great numbers, among the shore-living forms on the south end of the beach.

Polykrikos lebourae, sp. nov. Colony broadly ovate, consisting of eight zooids flattened laterally, the terminal ones being little more than half the breadth of the intermediate ones. A slight constriction often occurs about the fourth zooid (possibly only when the chain is about to divide). The separate zooids are not distinctly marked off from one another. The sulcus is continuous throughout the length of the chain and the longitudinal flagella, which are free from the point of origin, are long and conspicuous. The nuclei are two in number situated one in the anterior and one in the posterior half of the colony. Two forms occur, one in which the protoplasm is colourless, but contains at least one large coloured mass—probably of food material—and the other in which the protoplasm appears to be full of small yellowish brown chromatophores. There are no nematocysts. Length 56μ .

This is a shore-living species, so far never observed except on damp sand, and usually in company with other protozoa.

[N.B.—This species is the *only* one that has so far been observed at Port Erin. In the last report it was recorded as *P. schwarzi*, Bütschli, an error which has been pointed out to me by Dr. M. V. Lebour.]

Phalacroma kofoidi (E. C. Herd.)* I agree with Dr. M. V. Lebour that this form, described in the last report as *Amphidinium kofoidi*, var. *petasatum*, is not an Amphidinium at all, but should be included in the genus Phalacroma. The body

* See *Trans. L.B.S.*, Vol. XXXVI, 1922, p. 18, fig. 3.

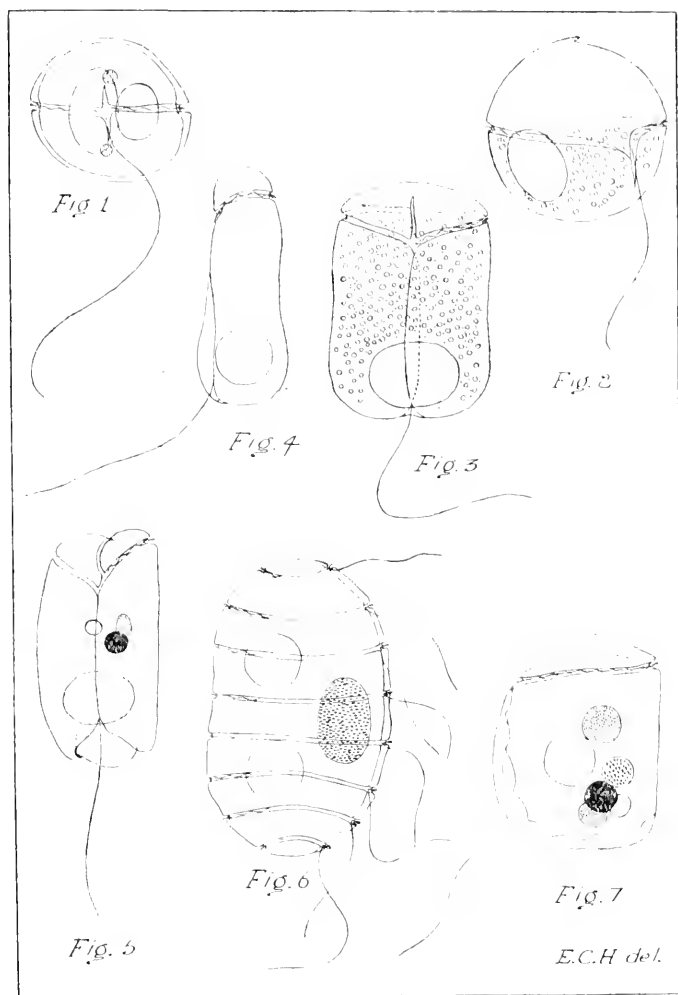
Fig. 1. *Glenodinium mounse.*Fig. 2. *Gymnodinium agile.*Fig. 3. *Amphidinium jb.cam.*

Fig. 4. The same (side view).

Fig. 5. *A. swissum.*Fig. 6. *Polykrikos lebouræ.*Fig. 7. *A. semilunatum.*

is enclosed in a bivalved shell, and traces of a list are distinguishable along the border of the sulcus. The general appearance and habit, however, are similar to those of *Amphidinium*, and it seems probable that this and the very similar laterally flattened species of *Amphidinium*, viz., *A. kofoidi*, and *A. semilunatum*, which occur on the shore at Port Erin may be taken as evidence of the close phylogenetic connection between the Dinophysidae and the Gymnodinioidae.

As two of the forms recorded in the Report of 1922, viz., *Amphidinium scissum*, Kofoid, and *Gymnodinium agile*, Kofoid, differ slightly from the types occurring on the Californian coasts, figures of them are included here for comparison with those of Kofoid (see Plate).

With regard to the bionomics of these shore-living forms, the following notes are of interest.

(1) On September 21st, 1922, a sample of damp sand containing *Amphidinium herdmani* was brought from Douglas and placed in a glass dish. During two days the organisms rose and sank in the sand synchronously with those on the beach. Their movements then became irregular and finally ceased. This is the first case in which any *habit* has been observed, the rhythmic movements persisting after the stimulus has been removed.

(2) Samples of as many species as possible were transferred to fresh water and the effect, after 24 hours, was as follows:—

<i>Amphidinium eludens</i> , <i>Gymnodinium placidum</i> , <i>Glenodinium monense</i> , and Diatoms.	}	Apparently unaffected, provided the change from salt to fresh water was not too rapid.
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A. asymmetricum, var. *britannicum*. About 60 per cent. dead.
 The rest apparently normal.

A. asymmetricum, var. *compactum*. Blown out and pale in colour—mostly quiescent, but a few swimming slowly.

NOTE.—Owing to a miscalculation, the measurements of the organisms given in the last report were overestimated. The following is a corrected list :—

A. asymmetricum, var. *britannicum*—50-60 μ

A. asymmetricum, var. *compactum*—40-50 μ .

A. cludens—30 μ ; *A. herdmani*—20-30 μ ; *A. klebsi*—20-40 μ ;

A. kofoidi—25-40 μ ; *A. pellucidum*—50-60 μ ;

A. scissum—50-60 μ ; *Gymnodinium agile*—15-30 μ ;

G. placidum—50-60 μ .

APPENDIX C (2)

A PLEA FOR THE ESTABLISHMENT OF A
BIO-GEOCHEMICAL LABORATORY.*

BY W. J. VERNADSKY.

(Member of the Academy of Sciences of Petrograd.)

Recent research has shown that the chemical composition of the earth's crust, down to a depth of about 20 kilometers is a function of the structure of the atoms and cannot be explained by purely geological facts and reasoning. We can study the chemistry of the earth: (1) by the methods of geo-chemistry, that is, by investigating the material of the earth in relation to the history of the atoms, and (2) by the methods of mineralogy, which studies complexes of the second order, that is, molecular and crystalline bodies. In geo-chemical research we think rather of the newer chemistry and physics of the atoms, while mineralogy deals with the older chemistry and physics of the molecules.

Progress in the observational sciences demands an organisation of laboratories and special research institutes. Isolated investigations are inadequate and the future history of science (and humanity) depends on collective research. It is true that thought must be individualistic and that mere organisation cannot replace it, *still* an isolated investigator, no matter how well equipped he may be, or however industrious or well endowed with scientific intuition, cannot, of himself, solve the problems of inductive science. He must have, in a limited period of time, a sufficient body of verified facts pointing in an unique direction. Thus organisation and collective research is, to a greater extent than we generally

* See also "La Composition Chimique de la Matière vivante et la chimie del'écorce terrestre." By W. J. Vernadsky. *Revue Générale des Sciences*, 30th January, 1923, pp. 42-51. The short paper published above is an abstract of another paper written by M. Vernadsky.

admit, an indispensable condition for scientific progress. Science is based on individual thought, but it must be organised so that the force of an isolated investigator may be multiplied.

Man's greatest asset is a new idea enabling him to penetrate more deeply into nature. History shows us that powerfully directive ideas are often lost in spite of our social organisation. They may be rediscovered, but something of their efficacy in human progress is lost. They rarely arise and we have no other way of nurturing them than by scientific organisation.

In no country does there exist any institute solely devoted to geo-chemical research. Data that are employed in such speculation as that of the chemical nature of the crust of the earth have been accumulated by geological, biological and agricultural laboratories and expeditions, but they have very often been obtained for other purposes than that of the study of the chemistry of the earth. Very often they are heterogeneous and of little value for geo-chemical research. The progress of the latter has, therefore, been impeded by the lack of a special focus of organisation for this kind of scientific work.

The study of the chemical elements in the crust of the earth assume different complexions according to whether we take it up from the inorganic or organic standpoints. This crust is an heterogeneous mass consisting of (1) inorganic materials, and (2) the bodies of living organisms. The distinction can be traced back to remote geological periods for we have direct or indirect evidence that life existed in Archean times: the principle of Redi—*omne vivum e vivo*—has no apparent exception in the results of geology for there are no indications of the occurrence of a process of abiogenesis. In stratigraphical geology inorganic matter is linked together with organic matter.

The scientific data of geo-chemistry are of unequal value with regard to inorganic matter, on the one hand, or to matter

displaying the phenomena of life on the other. The chemistry of the rocks, minerals, siliceous magmas, natural liquids and gases is fairly well known. The data are both quantitative and qualitative. No very risky hypotheses are involved, and the data form a not unsatisfactory basis for geo-chemical speculation. It is quite different with regard to the chemistry of the substances that compose the tissues of organisms. The cause of the difference inheres in the point of view of the biologists who look upon the organism from the point of view of its structure and activity, or at assemblages of organisms from the other point of view—that of their history. The point of view taken by the geo-chemist is rather that of the aggregate of organic matter in so far as it is responsible for geo-chemical phenomena. He studies living things from the statistical standpoint and so notes properties that may be neglected by the biologist. Life to him is something that has modified the chemistry of the earth's crust while to the biologist the latter is only part of the environment of the organism.

The geo-chemist must regard inorganic and organic materials from the same standpoint. The two categories of chemical substances are indissolubly connected for the elements continually pass from one to the other. Therefore they must be regarded in the same way. They have a morphology, a chemical composition, mass and energy.

By *Living matter* is meant the aggregate of the organisms of the earth.

By *Homogeneous living matter* is meant the aggregates of organisms of the same species.

By *Heterogeneous living matter* is meant aggregates of organisms of different species or races.

Thus, the total organic world is an aggregate of heterogeneous living matter. A tropical forest, a prairie, etc., are such heterogeneous aggregates. But a bottom-living marine

community, a field of wheat, and a forest of pines are homogeneous aggregates. The latter correspond to minerals and simple rocks, the former to rocks in general.

The biosphere, that is, the part of the earth's crust where we find life, is composed of rocks, minerals, water and gases—the inorganic materials—and of homogeneous living aggregates and their heterogeneous complexes. The total mass of the organic materials is very much less than that of the inorganic materials, but its significance is not less. On the contrary the significance of the organic matter is immense and tends to become greater as enquiry becomes more searching. Thus the two most important of chemical substances, from the geo-chemical standpoint, O_2 and CO_2 , are almost entirely products of life. The importance of living matter in geo-chemical investigation has long been demonstrated with regard to the elements O, N, C, and S, but it can now be shown that, in all, 29 elements are of significance, and possibly there are 11 others. The elements of which the history is controlled by the conditions of life form over 99 per cent. of the mass of the earth's crust. One might have deduced the importance of life in relation to geological processes by thinking about the way in which living matter accumulates solar energy on the earth's surface.

There is, therefore, need for an exhaustive series of analyses and evaluations of the living matter on the earth's surface. The data that exist are meagre, and are less exact than the methods admit. Until this deficiency is made good, geo-chemical investigation will be restricted in several directions.

There are, indeed, some evaluations of the mass of living matter existing in restricted parts of the earth's crust: thus we have estimates of the mass of marine plankton in certain regions, of the numbers of fishes in local seas, of the plants of the benthos, etc. There are also valuable data obtained in

the course of agricultural research. But in all these researches the object has been an economic one, and the relation to geo-chemical studies is indirect.

The mass of living matter on the earth is certainly not accidental. Is it characteristic of our planet? Is it constant? This problem has been in our minds since the time of Buffon and it has received very different answers. What relations exist between the total masses of different categories of organisms? Do these relations change? How are the different categories related quantitatively in respect of nutrition? What are the quantitative relations between, say, holophytic, holozoic, saprophytic, saprozoic, herbivorous, and carnivorous organisms? Is there any relation between the total mass of a category of organisms and its rate of reproduction? Is there a constant of reproduction? The solution of these (and other) problems require new data which can only be obtained as the result of the work of a special bio-geochemical institute. Their solution will lead to new problems and will introduce numerical data into a department of science (geographical distribution of plants and animals) in which this precision has been sadly lacking.

It is an astonishing fact that there is no single, complete quantitative analysis of the body of an organism comparable with the analyses of rocks and minerals that we possess. Organic analyses can only be compared with the analyses of rocks and minerals made fifty to sixty years ago. There are no analyses of many of the widely distributed genera of plants and animals, and no average quantitative analyses of the bodies of such categories as, say, marine animals, vertebrates, terrestrial invertebrates, cryptogams, etc. There is no average quantitative analysis of a phanerogam. The methods of analysis are not yet fully developed. Thus the water content of the body of a marine animal cannot be completely determined by drying at 100° to 120° C. Even the estimations of

the elements C, N, and H, to say nothing of the metals are not exact enough. There are many estimations of the "ash" of the bodies of plants and animals, but these cannot be referred to the living organisms. Much of this kind of work must be done over again and accompanied by spectroscopic research. The distribution of the rare elements in the earth's crust and in the bodies of organisms for instance, would be valuable both from the physiological and geo-chemical standpoints.

Therefore an important, modern scientific development must be the establishment of a Bio-geochemical Institute with the following objects :—

- (1) Elaboration of methods of evaluation of the masses of living organic matter belonging to different species, or other categories in restricted regions.
- (2) The complete quantitative analysis of the different homogeneous living materials and the formation of average results.
- (3) Complete quantitative chemical analysis of organic and inorganic materials rich in the rare earths, vanadium, chromium, etc.
- (4) Systematic quantitative average analyses of the commonly distributed homogeneous and heterogeneous organic materials.
- (5) Special problems such as the rôle of organisms in altering rocks and minerals.

The proposed Bio-geochemical Institute would seek to establish relations with all the existing biological and agricultural stations. It would set up an organisation for the obtaining of samples. It would elaborate methods of sampling.

APPENDIX C (3).

NOTE ON THE FUNCTION OF THE WATER VASCULAR SYSTEM OF ECHINODERMS.

BY W. J. DAKIN, D.Sc.*

Several times during the last thirty-five years the attention of zoologists has been called to the physiology of the water vascular system of the Echinodermata, and quite recently (1920) R. C. Bamber† has referred to the various theories which have been brought forward and has described a number of interesting experiments which she made in *Echinus esculentus*.

Attempts were made to test for a possible inward current of water through the madreporite by keeping specimens in coloured sea-water. In no case did any very definite colour show up in the stone canal, and these and other experiments appeared to indicate that there was no continuous current in either direction in the madreporic system.

The present author was interested in this work, especially since he had previously made a number of experiments on starfish and sea-urchins in the course of an investigation of the internal fluids of aquatic animals. The consequence was the initiation of a series of experiments to determine the effect of securely sealing up the madreporite, so that sea-water could not pass directly into the water vascular system. At the same time some sealed individuals were subjected to immersion in hypertonic solutions of sea-water.

After several trials, shellac dissolved in absolute alcohol and ether proved to be the best sealing material. A rather

* The author is indebted to Miss Bangham, B.Sc., and Miss Fordham, B.Sc., who carried out some additional experiments and also to Mr. Chadwick of the Port Erin Station.

† *Trans. Liverpool Biol. Soc.*, Vol. XXXV, p. 64. 1921.

strong solution was used and this was painted over the madreporite after the spines had been scraped off and the surface quickly dried with cloth and filter paper. A gentle current of air helped to dry the varnish. A number of specimens were used as controls, the same scraping and varnishing being carried out, but not over the madreporite. This was to eliminate the effect of the alcohol and ether treatment in the comparisons with untreated specimens.

A considerable number of Echini treated in the above manner were placed, together with untreated specimens, in one of the deep aquarium tanks of the public part of the Port Erin Station Aquarium. They naturally fell to the bottom. The next day all had crawled up the sides of the tanks to the surface of the water. They were gently detached and again dropped to the bottom. Usually the sea-urchins crawled up to a part near the surface. Day after day for two weeks at least the individuals with sealed madreporites crawled up as well as the others. They were able to use tube feet and were, in no way, visibly affected by the sealing, and they appeared remarkably healthy considering the treatment.

The conclusion is obvious. Either the leakage of seawater through the walls of the tube feet is much less than imagined by many authors or else the turgidity of the water vascular system is kept up by other means. The difficulty of finding regular inward currents in the stone canal is explained. Regular inward currents are not necessary to keep the water vascular system in action.

It is not possible to state, however, whether very small losses in the course of a longer period than two to three weeks are made good through the madreporite. The sea-urchins remaining in the tank after our departure from Port Erin were not studied again until October (six months later) when a letter arrived from Mr. H. C. Chadwick, A L.S. An *Echinus* had been found just dead in the tank and it was noticed that

the madreporite was sealed. Mr. Chadwick was, fortunately, able to dissect it, and he has communicated the following interesting particulars.

“The ampullae were quite abnormal. It was scarcely possible to distinguish individual ampullae. They looked more like a brown film along the sides of the radial vessel. The thought of degeneracy occurred to me but in view of the starved appearance of the intestine and the almost complete absence of food in it I thought it more likely that the ampullae had shared in the general starvation.” Unfortunately no one had noticed the particular specimen during the period preceding death and consequently it is not possible to state whether it was capable of extending and utilising its tube feet. It would appear, however, from the duration of life after the operation, that sealing the madreporite had not been attended by the symptoms that one would associate with the obstruction of such an important function as excretion. Perhaps it is too dangerous to generalise from one such specimen. The case, is however, rather interesting.

It remains to describe the effects of hypertonic solution of sea-water on the vascular system. In order to bring the latter into rapid contact with the changed outer fluid, the shell (after sealing the madreporite) was pierced and the coelomic fluid run out. The specimen was then held under the hypertonic sea-water. The result was a rapid retraction of the tube feet in the stronger hypertonic solution, and less rapid in the weaker ones and it often did not occur at all, at least for some time, in normal sea-water. The time of immersion was an hour. It was found that even after an hour in a solution $1\frac{2}{3}$ times as concentrated as sea-water, the tube feet would be extended on restoration of the animal to normal sea-water. A solution twice as concentrated seemed, however, to result in permanent injury. Many experiments were made with different solutions but all showed that the wall of the

vascular system acted as a semipermeable membrane and that the turgidity of the system was soon restored by osmosis after return to normal sea-water. It is of course impossible to say whether osmosis plays any part in keeping the water vascular system normally turgid. But it is evident that the system can function quite well for a long time after direct communication with the outer medium by way of the madreporite is destroyed.

APPENDIX C (4).

OTHER PUBLISHED WORK FROM THE DEPARTMENT
OF OCEANOGRAPHY, DURING THE YEAR 1923.

The following publications are not referred to in the preceding pages :—

Emeritus Professor Sir W. A. Herdman.

“Founders of Oceanography.” pp. 340, 28 plates,
19 text-figures.

(Ed. Arnold & Co., London. 1923.)

J. Johnstone, D.Sc.

“An Introduction to Oceanography.” 350 pages,
69 figures in the text.

(University Press of Liverpool, Liverpool. 1923.)

J. Johnstone, D.Sc.

“Marine Biology of the Irish Sea,” in “Merseyside,”
British Association Handbook, Meeting of 1923,
pp. 323-339.

[The following references are to the *31st Annual Report of the Lancashire Sea Fisheries Laboratory*, for 1922-1923.]

J. Johnstone, D.Sc. and A. Scott, A.L.S.

“Introduction and General Account of the Work.”
(pp. 26.)

J. Johnstone, D.Sc., W. C. Smith, and R. A. Fleming.

“The Irish Sea Cod Fishery of 1921-23.”
(pp. 13 ; 3 tables.)

J. Johnstone, D.Sc.

“On Some Malignant Tumours in Fishes.”
(pp. 18, 7 figs.)

R. J. Daniel, B.Sc.

“Seasonal Changes in the Chemical Composition of the
Mussel (*Mytilus edulis*).”
(pp. 24 : 6 plates.)

W. Birtwistle and H. Mabel Lewis, B.A.

“Scale Investigations of Shoaling Herrings from the
Irish Sea.”
(pp. 23 ; 4 figs. ; 3 tables.)

NOTES ON DINOFLAGELLATES AND OTHER ORGANISMS CAUSING DISCOLOURATION OF THE SAND AT PORT ERIN. IV.

By E. CATHERINE HERDMAN, M.Sc.
Zoology Department, University of Liverpool.

(Communicated May 8th, 1924.)

In the spring of this year (1924) daily records of the shore-living Dinoflagellates at Port Erin were made from March 24th to April 23rd inclusive, with the following results.

Forty-odd forms were figured and described, none of which are definitely identifiable as any previously described species. Many occupy an intermediate position between existing species and, in some cases, a series is found connecting not only neighbouring species, but also distinct genera. The series leading from *Amphidinium* to *Gyrodinium* is especially complete while several intermediate forms also connect *Amphidinium* with the Dinophysidae.

It would be useless to attempt to describe all these forms as new species or even as constant varieties, and indeed it seems that the validity of some of the existing species is questionable. For convenience, however, names must be given to some of the commoner types and, accordingly, a few of the more outstanding have been chosen and are here described with the note that they are probably not valid species.

Exuviaella marina, Cienkowski (Fig. 1). This species occurs in considerable numbers on the shore of the Lancashire coast near Freshfield, and the specimens from there show a modification, which is interesting in connection with the evolution of *Amphidinium*. In swimming, the longitudinal flagellum is often turned backwards, as in the Diniferidea, and a slight indication of the anterior part of a sulcus is visible. Thus the gap between *Exuviaella* and *Amphidinium testudo* (see below) is partly bridged over. (See additional note, p. 82).

Amphidinium testudo, sp. nov. (Figs. 2 to 5). Body broadly ellipsoidal, much flattened dorsoventrally. Ventral surface flat or slightly concave. Dorsal surface convex. Epicone very small, not projecting beyond the dorsal rim of the hypocone, but extending on the ventral surface at least one-third of the body length. Sulcus short: it does not extend onto the epicone nor does it reach the antapex. Girdle deeply impressed. Dorsal rim of the hypocone bent outwards as a projecting lip below the girdle. Nucleus situated in the posterior part of the body. Protoplasm colourless with yellow chromatophores and granules radiating from the centre of the body. Often one or more irregular, dark, highly refractile bodies are present. A colourless pellicle surrounds the whole body. Length, 20-30 μ .

[NOTE.—On several occasions specimens were seen larger than the type (about 35 μ) and broader and thicker (Fig. 5). They were considerably darker in colour and had no colourless surrounding pellicle. No flagella were observed in these specimens. On the Freshfield shore, in May of this year, an *Amphidinium* was found (Fig. 4) which appears to be a variety of the above, although intermediate between that and *A. operculatum*, Clap. and Lachm. The size, colour, and general form is the same as that of *A. testudo*, except that the body is somewhat pear-shaped, the anterior end narrowest, while the epicone is very considerably larger than in the type, and projects slightly beyond the dorsal rim of the hypocone. The greater part of the epicone is perfectly clear and colourless and so does not show up clearly except under the high-power. [The nucleus approaches that of *A. herdmani* in shape.]

Amphidinium klebsi, Kofoid (Figs. 6 to 10). At least six different types occur which grade into one another and some of which approach very near to *A. klebsi*, Kof. The extremes are so widely divergent that they would certainly be described as separate species, if the intermediate forms were unknown. In colour, the protoplasm ranges from glassy clear and colourless

(Figs. 8 and 10) to deep greenish brown and very granular (Fig. 6). Some are long, slender and very active forms, while others are broad and almost disc-shaped. Most of them have an orange or reddish spot in the epicone.

Amphidinium herdmanni, Kofoid (Figs. 11 to 13). This species is the one which was first noted in 1911, and is one of the commonest on the Port Erin beach. Besides the typical form there are many varieties in colour, shape, and cell contents. Thus, in Fig. 11 the protoplasm is colourless with numerous globular yellow chromatophores, in Fig. 12 it is greyish with a dark red spherule in the middle of the body, while in Fig. 13 the protoplasm is a very pale yellow with no chromatophores.

Amphidinium pellucidum, C. Herdm. (Fig. 16). This species is common round the old pier at Port Erin. Girdle considerably displaced—about twice its own width. Body shape extremely variable, some individuals being little more than half the length of others. Antapex sometimes (not always) notched by the sulcus. Nucleus roughly central. A reddish or orange spherule is present in all typical specimens near the junction of the girdle and the sulcus. Some coloured bodies (? food) are nearly always present in the posterior region of the hypocone—some deep red and some brown. (In division these coloured bodies seem to be shared evenly between the resulting schizonts.) Many varieties of colour and shape occur and a complete series leads over to *A. scissum*, Kofoid (Figs. 14 and 15).

Division in A. pellucidum. Two stages in division are seen from time to time, although the complete process has not been watched in a single individual. In one stage (Fig. 17) the two schizonts lie almost side by side (as in *A. herdmanni*—see *Trans. L.B.S.*, 1922). In the other (Fig. 18) they are much more loosely attached and lie with the apex of one at the level of the girdle of the other—that is, they lie almost end to end in typical chain formation. In this case both schizonts have longitudinal flagella, while, at the former stage, only one

flagellum has been observed. Probably Fig. 17 represents the earlier stage and, later, the two products of division slip over one another to form the second stage seen in Fig. 18.

Amphidinium bipes, sp. nov. (Fig. 19). Total body-length about 1·4 transdiameters. Flattened dorsoventrally. Epicone roughly triangular, very slightly concave anteriorly and highest at the left side. Hypocone large and more convex on the right side than on the left—very deeply notched at the antapex, so as to leave two posteriorly projecting processes. Sulcus a broad shallow furrow on the hypocone and continued forward as a narrow groove on the epicone. Posterior flagellum long, free from its origin and often turned forwards. Protoplasm colourless and granular. Dark brownish green granules fill the posterior horns of the hypocone. A highly refractile body sometimes lies just anterior to the antapical notch. Nucleus to the right of the sulcus. Length about 30 μ .

Amphidinium latum, Lebour Ms.* (Fig. 20). A minute and extremely active form. Flattened dorsoventrally. Epicone small and button-shaped. Hypocone broadly sac-shaped and very slightly notched at the antapex. Protoplasm colourless and transparent, with bright green globular bodies (? chromatophores or food bodies) and often a reddish yellow body somewhere in the hypocone. Nucleus roughly central in position. Length about 10 μ .

NOTE.—Very variable in form. Some almost twice as wide as others.

Amphidinium ovum, sp. nov. (Fig. 25). Body ellipsoidal and flattened dorsoventrally. Girdle rising to the left shoulder and thence running in a descending left spiral to join the sulcus about 0·4 of the body-length from the apex. Sulcus runs from the girdle to the antapex as a groove which is deeply overlapped by its left margin. From the antapex, it is continued as a narrow furrow up the dorsal side almost to the

* I believe that this form is probably identical with that described as *A. latum* by Dr. M. V. Lebour in her new memoir on Dinoflagellates, which is now ready for publication.

level of the girdle. The longitudinal flagellum extends about twice the body-length beyond the antapex. Nucleus posterior. Yellowish brown chromatophores are arranged in radiating lines running from the centre. Length about 30μ .

Amphidinium manannini, sp. nov. (Fig. 21). Body broadly ellipsoidal—flattened laterally. Epicone broad and low, slightly notched at the apex by a forward prolongation of the sulcus. Sulcus rather deep and extending almost to the antapex. Protoplasm colourless and hyaline. Nucleus situated in the posterior part of the body. Another colourless refractile body lies in the mid-ventral region. Length about 20μ .

Amphidinium vitreum, sp. nov. (Fig. 22) [Only one specimen.] Body flattened from side to side. Very thin slender form. Epicone small and rather flattened. Hypocone sac-shaped, more convex on the ventral than on the dorsal surface. Girdle higher on the left shoulder than on the right. Sulcus extending from the girdle to the antapex—very deeply impressed. Protoplasm perfectly clear and colourless. An elongated refractile body lies near the dorsal surface. Nucleus probably just ventral to this. Length about 20μ .

Phalacroma kofoidi (C. Herdm.) (Fig. 23). Besides the common form described in *Trans. L.B.S.*, 1922 and 1923, another occurs which may be a variety of the same species. In general body-shape it is very similar to *Ph. kofoidi*, but the protoplasm is perfectly colourless and granular with various coloured food bodies. No suggestion of a theca was observed except along the dorsal edge of the hypocone, where the irregular outline suggests covering plates. Nucleus ellipsoidal and situated in the posterior part of the hypocone. Length about 30μ .

Phalacroma ebriola, sp. nov. (Fig. 24). Body roughly ellipsoidal, flattened laterally. Epicone small and tilted back to the dorsal side. Body seems to be covered by a very thin hyaline shell, which is produced as a slight list on the

left border of the sulcus. Protoplasm clear and colourless, but usually containing coloured food bodies. Two large refractile bodies (? vacuoles) are situated in the anterior region of the hypocone. Nucleus posterior. Length about 40μ .

[These three types of shore-living Dinophysidae are interesting in that they occupy a border-line position, having many points of resemblance to *Amphidinium*.]

Gymnodinium variabile, sp. nov. (Figs. 35 to 45). A dozen or more small forms of *Gymnodinium* are common. These differ only slightly in shape, being nearly circular in ventral view and more or less flattened dorsoventrally. Girdle approximately equatorial, its ends meeting with little or no displacement. Sulcus varies from a shallow groove, reaching from the girdle half way to the antapex, to a well marked furrow, extending to the antapex and with a forward extension onto the epicone. Nucleus, which is spherical, lies roughly in the middle of the body. One, two or three orange or reddish bodies lie in the region of the sulcus in most of the specimens. Protoplasm usually colourless or pale yellow with or without colourless or greenish brown granules. Length from 8 to 40μ .

[Probably some of the smaller types included here are really spores of some other, possibly armoured, Dinoflagellates, while others may represent different stages in a single life-history.]

Gymnodinium incertum, sp. nov. (Fig. 32). [Only one specimen.] A small form, somewhat flattened dorsoventrally. Epicone hemispherical in ventral view, larger than the hypocone. Hypocone rather more flattened than the epicone and considerably shorter. Girdle post-median, its ends displaced about 0.2 of the total body-length. Sulcus short—not extending onto the epicone nor reaching the antapex. Protoplasm colourless with several rather large very pale green chromatophores. Nucleus central (?). A small reddish body lies near the proximal end of the girdle. Length 15μ .

Gymnodinium glandula, sp. nov. (Figs. 30 and 31). Body ovoid and flattened—somewhat asymmetrical. Epicone helmet-shaped with the apex produced into a sharp point, which is bent backwards so as to lie closely along the surface. Girdle post-median—deeply impressed—its ends meeting without displacement. Hypocone only half the height of the epicone, and not quite so wide. Sulcus extending forward a short distance onto the epicone (possibly not in all of the larger specimens). On the hypocone it runs posteriorly and obliquely to the left. Longitudinal flagellum nearly twice the length of the body. Nucleus spherical and situated in the middle of the body. Protoplasm colourless with pale greenish highly refractile granules. In larger specimens a red body is often present in the epicone and, in one, a large yellow body to which the red body is attached (Fig. 30). Length 20 to 35 μ .

Gymnodinium agile, Kofoid (Fig. 29). The form hitherto identified as *G. agile* differs from the Californian species in several points besides those already recorded (*Trans. L.B.S.*, 1922 and 1923). The borders of the sulcus are produced posteriorly into sharp ridges or spines, the nucleus is situated in the epicone (? always) while the protoplasm, always colourless, may be hyaline or densely granular. Length, 20 to 30 μ .

Gyrodinium lebourae, sp. nov. (Fig. 28). A small and very active form. Body ellipsoidal, hardly flattened dorso-ventrally. Girdle a descending left spiral, its ends displaced about one-third of the total body-length. Sulcus extending to the antapex. A small red body lies near the posterior end of the girdle. Length about 15 μ .

A practically complete series of forms connects the typical species of *Amphidinium* (such as *A. herdmanni*), through *A. britannicum*,* Lebour, and *A. britannicum* var. *compactum* to *Gyrodinium*. One form (Fig. 27), while approaching closely, in general appearance under the low-power, to

* Described in previous reports as *A. asymmetricum*, Kof., var. *britannicum*, C. Herdm. and *A. asymmetricum*, Kof., var. *compactum*, C. Herdm.

A. britannicum, var. *compactum*, certainly cannot come under any definition of *Amphidinium*. for the epicone is larger than the hypocone, while the girdle runs in a steep descending spiral. Unfortunately, the origins of the transverse and longitudinal flagella have not been observed.

NOTE.—I do not think it is probable that all these different forms have appeared newly at Port Erin. In fact, I am almost sure that I have seen many of them before. Undoubtedly the micro-fauna of the beach was much more varied this spring than is usual at that time of year, but my explanation of the forty-odd new forms I have figured is, that it was only after I had become accustomed to the more common typical forms, that I was aware of the many variations linking up the species and genera,—variations which I had hitherto passed over or classed with one or other of the commoner types.

ADDITIONAL NOTE.—At the end of August some observations were made on the Dinoflagellates inhabiting the beach sand at Woods Hole, Massachusetts. It is somewhat surprising to find that many of the common forms are identical with those occurring at Port Erin, while others are evidently only local varieties. The following is a list of the species identified at Woods Hole :—

Exuviaella. Three species or very distinct varieties, one of

which is practically the same as that shown in Fig. 1.

Prorocentrum micans, Ehbgs.

Prorocentrum scutellum, Schröder.

Glenodinium monense, C. Herdm.

Amphidinium klebsi, Kofoid. Many varieties as at Port Erin, grading into *A. operculatum*, Clap. and Laehm. and *A. herdmanni*, Kofoid.

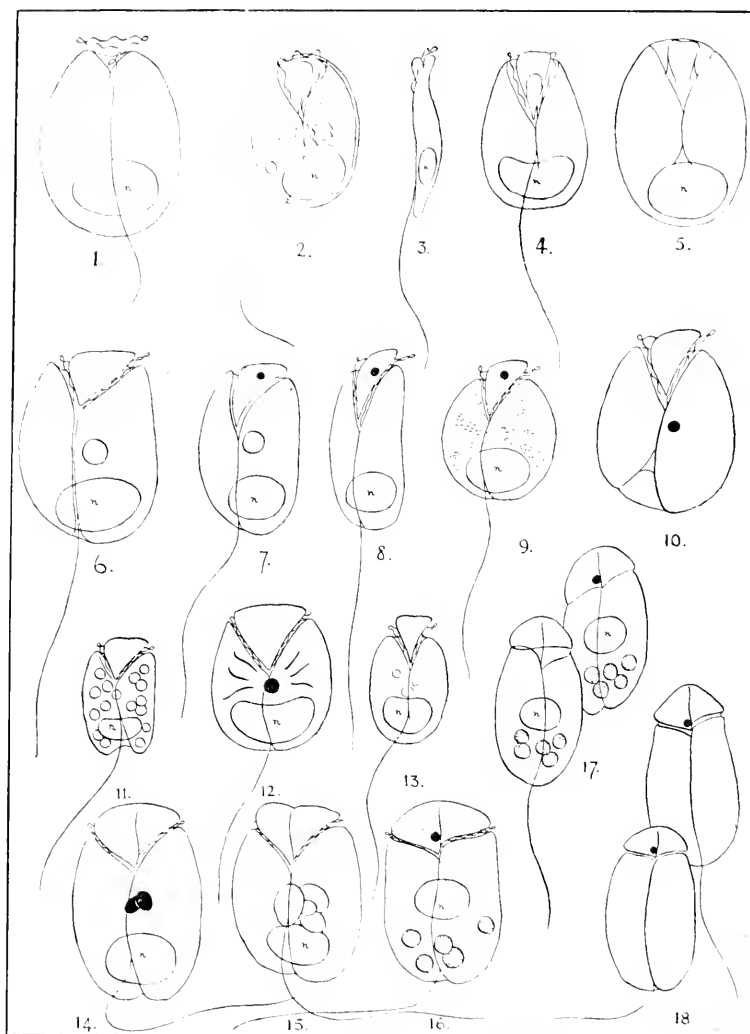
A. testudo, C. Herdm.

A. pellucidum, C. Herdm. Yellow variety.

A. britannicum, Lebour, grading into a new species of *Gyrodinium*.

Polykrikos lebourae, C. Herdm.

Dinophysis ebriola, C. Herdm.



1. Variety of *Exuviaella marina*.

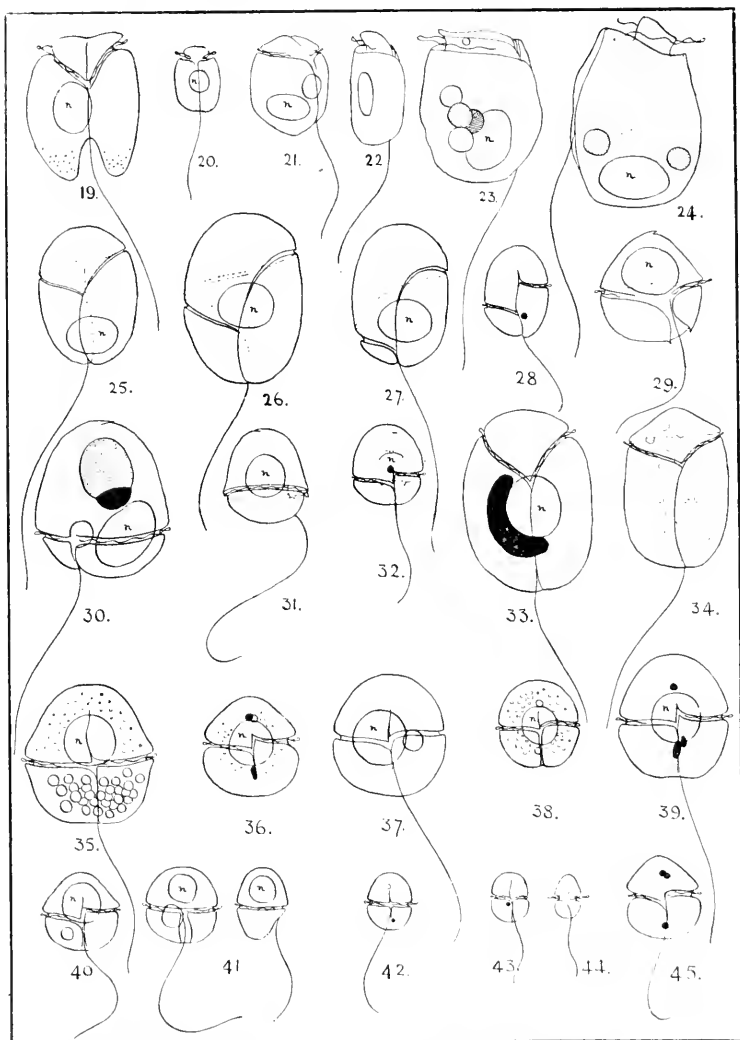
2 to 5. *Amphidinium testudo*.

6 to 10. *A. klebsi*.

11 to 13. *A. herdmanni*.

14 to 18. *A. pellucidum*.

n.—nucleus. (Red and orange
bodies are figured as black.)



- | | |
|---|--|
| 19. <i>Amphidinium bipes</i> . | 28. <i>Gyrodinium lebourae</i> . |
| 20. <i>A. latum</i> . | 29. <i>Gymnodinium agile</i> . |
| 21. <i>A. manannini</i> . | 30 and 31. <i>Gymnodinium glandula</i> |
| 22. <i>A. vitreum</i> . | (ventral and dorsal views). |
| 23. <i>Phalacroma kofoidi</i> (colonless | 32. <i>Gymnodinium incertum</i> . |
| variety). | 33 and 34. Intermediate types |
| 24. <i>Ph. ebriola</i> . | connecting <i>A. herdmanni</i> and |
| 25. <i>Amphidinium ovum</i> . | <i>A. britannicum</i> . |
| 26. <i>A. britannicum</i> var. <i>compactum</i> . | 35 to 45. <i>Gymnodinium variabile</i> . |
| 27. Single specimen intermediate | |
| between <i>Amphidinium</i> and | |
| <i>Gyrodinium</i> | |

REPORT ON THE INVESTIGATIONS CARRIED ON IN 1923 IN CONNECTION WITH THE LANCASHIRE SEA-FISHERIES LABORATORY AT THE UNIVERSITY OF LIVERPOOL, AND THE SEA-FISH HATCHERY AT PIEL, NEAR BARROW.

EDITED BY

PROFESSOR JAMES JOHNSTONE, D.Sc.,
Honorary Director of the Scientific Work.

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INTRODUCTION.

Plankton Investigations.

No new lines of investigation have been taken up during 1923, and work has been restricted to completing, as far as opportunity allowed, researches that were already begun. A summary of the investigations into the plankton of Port Erin Bay made during 1907-1920 has now been completed by Messrs. Scott and Chadwick and myself, and has been published as a separate book*. It is hoped that this work (which represents a considerable experience of the plankton of a restricted sea area) may be useful both to investigators and University students. While the description of the collections was being completed by Mr. Scott, an investigation of the plankton

* "The Marine Plankton," with special reference to investigations made at Port Erin, Isle of Man, during 1907-1914. 194 pages, 20 plates, 6 graphs, and 42 tables. University Press of Liverpool, Ltd., 1924. Price, 12.6. By J. Johnstone, A. Scott, and H. C. Chadwick, with an introduction by Sir William Herdman.

found in the open-air sea-water ponds, at Port Erin, was commenced, in the hope that certain minor points might be elucidated. The gatherings made have now been worked up by Mr. Scott, and form the subject of a short paper contained in the present report. Some remarkable differences between the plankton of the ponds and that of the adjacent open sea have been noted: for instance, one genus of diatom (*Skeletonema*) which was never seen in all the fourteen years' work on the plankton of Port Erin Bay, occurred in great abundance in the spawning ponds. Without doubt it was also in the sea during the period of investigation, but in such small quantity that it was not recorded (for, it must be noted, all plankton work is done, not on the complete collections, which would be impracticable, but on samples taken from each collection). Some combination of conditions which occurred in the pond, and not in the sea outside, enabled these very few diatoms to multiply until they formed the bulk of the catches made.

Clearly future work on the marine plankton must follow lines suggested by such an experience as this. Merely to collect and describe plankton from the sea—or even to correlate the data so obtained with such data as sea temperature, salinity, winds, sunlight, etc., is not likely to lead us very far into a knowledge of the causes of the changes in the abundance of the organisms that form the ultimate food materials of all marine fishes. Sustained work on the life-histories and physiology of the microscopic animals and plants that make up the plankton is now necessary, and the methods of artificial culture developed by Allen and Nelson give a starting point and suggest the technique which may be adopted in such investigations. It is hoped that this line of investigation may be followed in the near future by workers who have the opportunity: doubtless, its results will enable us to interpret the results of such statistical investigations as those that I have referred to in the foregoing pages.

Directed Research.

A certain amount of work has been carried on under the direction of the Ministry of Agriculture and Fisheries (in consideration of a small grant made to the University of Liverpool). Part of this work has consisted in the description of plankton collections made on lightships in the English Channel and in the North Sea, and the Ministry has made use of Mr. Scott's very specialised knowledge of the subject. A report has been made. Some work on the cod has also been done by Messrs. Scott and Smith and by myself. The Ministry have had a general investigation of the cod in British seas in progress, and we were invited to make a report on the life-history of the species and the fishing in the northern part of the Irish Sea. Summaries of the occurrence of the various parasites and diseases that infect the cod in the Irish Sea and elsewhere have also been made by Mr. Scott and myself. These results are recorded in a report published by the Ministry during 1924.*

Another part of the directed research undertaken for the Ministry consisted of investigations into the life-history and fishery of the herring in the Irish Sea.

Herring Investigations.

Three papers on this subject are contained in this Report. Mr. Scott describes the food contents of the stomachs and intestines of herrings caught in the sea off Isle of Man in 1923; Mr. W. C. Smith gives a general account of the fishery in the Irish Sea in so far as it was represented by the catches landed at Manx ports, and Mr. W. Birtwistle and Miss H. M. Lewis report upon extensive collections of herring scales that were made at Manx ports in the fishing season of 1923. The method of "scale reading" elaborated by the Norwegian investigators has been adopted: by this means the ages of

* *Fishery Investigations*, Ser. II, Vol. VI, No. 1.

the fish composing the samples have been ascertained. At the same time the lengths of the fish were measured and the conditions with regard to maturity were observed. Numerous data have been collected and tabulated by Mr. Birtwistle and Miss Lewis and the materials now exist for a further, intensive investigation of the reproductive processes of the local herrings. One has the conviction, in considering these results that much investigation must now be undertaken with regard to the physiology of the herring—the reasons, for instance, why some Irish Sea fish spawn when the sea temperature is falling from the mean towards the minimum annual values, while others spawn when the temperature is rising from the mean towards the maximum. As in the case of the plankton such physiological work will be necessary in order to interpret statistical data, such as those given in the present Report. Mr. J. R. Bruce, of the Port Erin Biological Station, has made an investigation into the composition of the flesh of herrings belonging to different year-classes and such work as this appears now to be of much importance in relation to the movements and spawning seasons of fish in the sea.

Investigations into Malignant Disease in Fishes.

Several interesting examples of malignant tumours are described in pp. 183-213 of the present Report.

The subject of the *causation* of cancer-like disease in man is so very important that some remarks on the occurrence of this kind of affection in fishes are relevant. It cannot be claimed that the number of examples of neoplastic growths in marine fishes is sufficiently great to enable us to generalise. But the difficulty of obtaining such material is great and if attention is drawn to the interest of the investigation good may be done. Besides even the little that we do know is very suggestive. I note, then, the ease with which these fish tumours can be identified when we use only such a book on

human disease as, say, Adami's "General Pathology." Sarcomas, ordinary and melanotic, epithelioma, angiomas, goitre, etc., in fish are all exceedingly like the affections so-called in man. The minute structure of the morbid tissues in the fish may be exactly like that seen in the figures in the books on human morbid histology. So similar are they that I doubt if even a very experienced pathologist would be able to say, from mere inspection of a microscopical preparation, whether it was human or piscine. To a morphologist who knows the great similarity in the minute structure of the tissues of all the vertebrate animals this result is not, of course, surprising. When this investigation was begun I hoped that it might be possible to find a piscine type of malignant tumour—something exclusive to marine fish and not seen in the mammalian animal. Of course, the data obtained so far are few, and this result may yet be obtained—if it can be obtained the knowledge is sure to be valuable.

One result is just foreshadowed (though it may be quite erroneous)—in the tumours of fishes seen so far *there is no instance of a carcinoma*. Carcinomata we may, perhaps, regard as the true human "cancers." I find, in the literature, only one record of a piscine carcinoma (in the 1st Report of the British Institute of Cancer Research). It would be highly interesting if this result could be verified by the examination of a large number of fish neoplasms and so enable us to make an important preliminary generalisation. It is to be hoped, then, that all fish tumours may be carefully investigated as to their histological nature. Meanwhile it is interesting, at all events, to note that many forms of malignant disease in man can be paralleled by similar disease in fishes, and the parallelism goes as far as fine microscopical details.

The Necessity for a truly Comparative Study of Cancer.

Clearly we ought to have much more information than is at present available as to the zoological distribution of

“cancer.” Very little is known as to the occurrence of such disease among birds, reptiles, and amphibia and, as we have just seen, much more remains to be done among the fishes. The animals, other than man, that have been studied are mainly the mammals, and among these it is chiefly domestic species that are investigated—those that we call “experimental animals,” as, for instance, mice. Now all this cannot be called “comparative” pathology in any real sense because the anatomy and physiology of the mammalian (and particularly the domestic and stock) animals are remarkably uniform. In many cases a domestic animal can be substituted for man in the study of disease and a good deal of what we do know with regard to “human” pathology has resulted from this kind of experimental investigation. Comparative research dealing only with the mammals is, of course, highly important in that it may be concerned with remedial measures, or with the prevention of disease, in those cases where the cause of the affection is known (as in tuberculosis, for instance). Even within the limits of the human species much has been done. Thus, age, sex and the incidence of cancer have been correlated; occupation and the susceptibility to cancerous disease have been correlated (as in the case of paraffin oil workers and their tendency to acquire malignant skin diseases. Race and the susceptibility to cancer has been investigated but without much result of note, and this is because of the difficulties of making such research in the cases of savage peoples—a pathological mission to the Eskimos could not fail to be of much value to medical science if it were practicable. Material environment in association with the disease has been studied (as in the cases of “cancer houses,” or with McCarrison’s fine investigation of goitrous disease and water supply in Northern Indian villages). Now, important as this line of work undoubtedly is it does not seem to lead us nearer to the discovery of the cause of malignant disease, and so the field of

investigation must be widened. Man and the domestic animals are far too like each other in their modes of functioning, and it is vain to call any research a comparative one that restricts itself to such species. Had comparative anatomy been so limited its results would have contained very little of general interest. On the other hand comparisons between what we know of cancerous disease in the mammals on the one hand and in the lower vertebrates on the other are likely to be of much more significance in the search for a casual process, or agent. Still more may we anticipate success when investigation of disease is extended to the invertebrate and plant organisms—that is, the study of disease in the general sense and not simply research into parasitic organisms and the affections which they induce carried out with a predominantly economic outlook on the problem. Again, we may note the success that has attended exhaustive comparative anatomical and embryological research with respect to the light that such work has thrown on the evolutionary history of animal and plant organisms.

The difficulties of making an exhaustive study of comparative pathology are, of course, enormous ones, because we must have that intimate knowledge of the conditions of normality and abnormality in the "patients" that are possessed by experienced physicians with respect to men and women. How are we to know when a fish is diseased? As a matter of fact specimens come to the laboratory that are said to be diseased, but are not really so. Few people except the fishermen and the naturalists who become thoroughly familiar with some species of fish by making very numerous routine observations can have such a knowledge of what a normal fish is like and what appearances are abnormal or pathological. Much more difficult is the recognition of disease in invertebrate animals and many laborious investigations such as that made by Dr. Orton with regard to the Thames oysters must be

carried out before we can make a really comparative study of disease in the lower animals. It is unfortunate that the opportunities for making these investigations only arise when the animals concerned (oysters, bees, or grouse, for examples) are "economic" ones. A really exhaustive series of examinations of any one invertebrate following some routine practice (as, for instance, a series of biometric investigations) would thoroughly familiarise a naturalist with normal characters and would enable him to draw the attention of others to abnormal appearances. Comparative pathology must embrace as wide a field of study as medical parasitology—which, it should be noted, is conspicuously successful just because of the large quantity of data accumulated by the purely systematic work carried on by zoologists in the eighteenth and nineteenth centuries. Here, again, one may note that exhaustive routine examinations of any one form of animal for its contained parasites lays a foundation for applied parasitological work.

Comparisons between widely different kinds of animals, in respect of their susceptibility to malignant disease must be made, and it is in this direction that new light on the causation of the diseases in question may come. Is carcinoma rare among marine fishes, and frequent in mammalia? Does carcinoma of the thyroid occur very frequently in fish reared in cultural establishments but very infrequently in fishes living in the wild? Why is thyroid carcinoma frequent among trout reared in North American hatcheries and infrequent in similar hatcheries in Scotland? Are there immune species? It is stated by Gaylord and Marsh that trout that are injured by the copepod parasite *Lerneonema* are susceptible to thyroid disease. Feeding with cooked flesh meat increases the susceptibility to thyroid carcinoma, while the tumours may regress when cooked meat or natural, live molluscs are substituted. If chronic irritation is a competent cause of cancer in man why is the typical and long-continued irritation set up by the

presence of a *Lernæa* on the ventral aorta of a whiting, or a *Lerneonema* on the eye of a sprat not followed by a malignant tumour. Does carcinoma or sarcoma extend by fragments of the tumour tissue carried in the blood or lymph streams? if so, what are the differences in the nature of the disease in fishes and mammals where the blood and lymph circulations differ greatly? If cell embolisms in the lungs of man start metastatic cancer growths, why does one not find such growths in the gills of fishes—which form a capillary system corresponding to that of the lungs in man? Why is there an apparent high frequency of sarcomatous growths in the deeper layers of the skin, or in the myotonic, connective tissue septa of fishes? These are some of the questions that, even now, are suggested by comparative studies. They are put in an hypothetical form because the mass of data on which they are based is far from adequate. To make it adequate would, unfortunately, mean an immense amount of routine observation carried out by competent zoologists at an expense that would not commend itself to practically-minded people. The search among thousands of crabs, or whelks, or copepods, for diseased conditions is not the sort of investigation that makes powerful appeal for public assistance, yet it may be very useful in providing data for a real system of comparative pathology. Even with fish, and considering the numbers of people who are interested, in one way or other, with these animals, the process of collecting examples of diseased conditions is a very slow one.

Cancer a Biological Problem.

The lines of investigation that are suggested here are obviously general biological ones. To begin with, a vast amount of purely descriptive work might be undertaken merely to find out what is the zoological distribution of malignant disease and then correlations between the variations

in the nature of this disease, or in its incidence, might be set up with the variations in the conditions of life of the animals studied. The somewhat sensational results obtained by Dr. Maud Slye in relation to mouse carcinoma also suggest purely biological researches: these results indicate that cancer in mice—and even the forms of the cancer—are inherited, and that the modes of inheritance and transmission are Mendelian ones. These results, if confirmed and extended to man are certainly depressing ones from the eugenist's point of view for, however easy it might be to eliminate cancer from mice by selective breeding it would be apparently impossible to do so in the human species—where the disease usually declares itself only after the reproductive period has commenced. The Mendelian mode of inheritance may, however, be far more characteristic of domesticated, than of wild animals and, at all events the problem of hereditary transmission of the disease in aquarium kept animals has to be investigated. Here the technique indicated is purely biological—though the difficulties are enormous.

Statistical and purely descriptive results, obtained on the lines suggested above would not, of course, be sufficient. Obviously much more must be known with regard to the minute structure of the tissues that may take on malignant growth. The histology of fish cancers suggests a more exhaustive examination of the modes of growth of the connective tissues than has yet been made: also research into the nature of the lymph spaces in fish muscle, into the arrangements of the capillary and nerve networks and into the variations in structure of the integument. Such investigations would also necessitate a close study of tissue growth in artificial media—a method of investigation that is already practised with much success in the Cancer Institutes, and which was applied by G. H. Drew, at the Plymouth Laboratory, to invertebrate animals.

One only discovers, after some reflection, the unique biological interest of cancerous growths. *They are the evidence of a positive attempt on the part of the organism to destroy itself.* In ordinary diseases the conditions are such as are due to mechanical injury, chemical injury (poisoning), physical injuries (heat, electrical stimulation, X-ray injury, etc., etc.), infection by parasites, failure of regulation or of secretion, degenerations of one kind or another, etc. It is to be expected that in all these cases the organism should make positive attempts at repair, etc. Thus there is regeneration of injured parts, elimination of the products of injury of the tissues, defences by phagocytes or anti-bodies against parasitic agents or their products, vicarious functioning of some organs to compensate for the loss of functioning of other injured organs, etc. Disease, as we know it, is nearly always accompanied by natural healing processes—that is, active and purposeful, and often successful responses to the morbid process itself.

All these are *adaptive responses*, as for instance, all regenerations of lost tissues. Other adaptive responses characteristic of normal functioning are, for examples, the increase in the mass of the heart in the athlete, the development of muscle tissue in response to increased use, the formation of skin callus where pressure (say that of holding a tool) is experienced, thickening and browning of the skin in men exposed to wind and rain, increase in the fur of animals exposed to low temperatures, whitening of the fur in animals living on snow-covered land, etc. It is characteristic of such adaptive responses that they are purposeful and effective from the point of view of the self-preservation of the individual animal.

Non-adaptive responses cannot be ascribed this purposeful character. Variations in mere colour of skin, eyes and hair among civilised people, for instance, do not seem to have much significance in the struggle for existence. Most of the little points of difference that characterise species—

such as the number of scales along the lateral line of a fish. the numbers of rays in the fins, the numbers of vertebrae or spines, colours, etc.—these do not appear to have adaptive value, or at least it is remarkably difficult to show what is their utility to the animal exhibiting them. They are, in a way, accidents of development—racial or individual—or luxuries.

A malignant growth shows us something quite different still—it is the expression of what we may call a *malign response*. Assuming, for the moment, the widely accepted hypothesis that malignant tumours are “caused” by chronic irritation (the smoking of clay pipes, continual contact of oil, etc., with some part of the skin, unusual deposit of pigment in the skin, foreign bodies in the lungs, etc.), we have what is biologically a very extraordinary result. We should expect that the tissues would react to these irritative stimuli by some *protective* device: thus the egg or larva of a parasitic animal deposited in the tissues is usually surrounded by a fibrous capsule, and degenerates; the heads of tapeworms that are fixed in the pyloric caeca of the cod become changed and the surrounding tissue becomes hard and capsular; the trematode parasite, or other foreign body, that becomes lodged in the mantle tissues of a pearl oyster is invested in a sac which then destroys the intrusive body by secreting lime round it and so on. Galls in plants are examples of the same useful reaction. The tissues thus make an active and adaptive response to the irritative stimulus and this response is of such a nature as to shield the organism from a harmful agent. The latter is, indeed, destroyed. Such is the usual benign response to chronic irritation.

But in a sarcoma, say, quite a different reaction is produced. The irritation causes, or stimulates the contiguous cells to divide and grow and again divide. That is, a process of proliferation of the connective tissue cells begins—and

continues. This growth proceeds far beyond the area of irritation and it intrudes itself into, or infiltrates the adjacent tissues. The latter are destroyed and the proliferating tissue continues to extend itself. So we find a tumour such that where there ought to be a typically arranged system of muscles, blood vessels and nerves, compactly bound together by connective tissue, there comes to be nothing but a mass of connective tissue, the existence of which is meaningless from the point of view of the organism. But this tumour still continues to grow without limit until it can no longer be nourished, when necrotic changes occur in its substance, and toxic products are formed which diffuse out into the healthy parts of the body. If the tumour is vascular, or if it stands in connection with a system of lymph vessels, parts of its substance become detached and are carried to other regions of the body where they begin to grow just like the initial tumour. The end is, of course, the death of the animal.

This is a malign response to the irritative stimulus and it is something that is offensive to all our notions of life itself. Mere destruction of the tissues by a traumatic or chemical injury we can understand - the organism is sure, somehow or other *to endeavour* to repair such an injury even if the response should be unavailing. But that a comparatively feeble (though long-continued) local irritation should induce the tissues to form a malignant tumour violates our conception of a living organism as something that so adapts itself to the changes in the environment as to enable it to survive.

Of course the hypothesis of chronic local irritation as the cause of a cancerous tumour is not one that can be sustained—at least by studies of malignant disease among fishes. Probably it cannot be sustained in the case of man. We are almost compelled to seek for the causes of malignant growth in the nature of the tissues themselves. It would appear (we consider fish here) as if the connective tissues that are in the skin or

lie between the muscle fibres are always ready to start growing without limit, of themselves. *Then* some irritative stimulus might be thought about as acting like a trigger, so to speak, and starting off the process of proliferation. Physically the irritative stimulus would initiate a *releasing transformation*, just as a spark might induce an explosion, or as a crystal added to a solution might induce the solution itself to crystallise. But it is difficult to convince oneself that such a releasing transformation is the result of local irritations in fishes. Far more likely is it that the proliferative process that forms a tumour is initiated by some change in the relations of the proliferating, to the surrounding tissues.

Comparative embryology helps us here. In an early stage of a sea urchin egg there are, say, 16 cells in the embryo. Each cell is equal in its *potency* to any of the others—that is, it is able to give rise to any part of the body of the animal that results from the development of the embryo. Really it gives rise to only one part and experiment shows that its fate, or its developmental result, depends on its *position*—that is, on its relations to the other cells. When this relation is changed the fate of the particular cell changes. What any particular cell, in the early stage of an embryo, is going to become is a function of its position with regard to the other cells in the complex.

So what the cells of the connective tissues in the sub-integumental tissues of a fish, such as the cod, will do depends on their relations to the surrounding tissues—or rather on their relations to the processes that go on in the latter tissues. We see clearly, at the growing margin of a fish sarcoma, the minimal packing of cells and fibres between the muscle fibres becoming more abundant, while, at the same time, the muscle fibres themselves are shrinking and finally disappearing altogether. Which of these processes initiates the other? Possibly some changed modes of functioning of the muscles,

or the nerve nets that surround them, or of the blood vascular or lymph channels, may have, so to speak, removed an inhibition on the growth of the connective tissue cells. Starting from this idea (which is, of course, not a new one) it might appear that experimental physiological work might throw some light on the processes involved, particularly if carried out along with extensive research on the growth of connective tissues in artificial media. Possibly this investigation may be easier in the cases of fish (if only we knew more about their normal physiology) than in the cases of mammals. Possibly the result (providing that further observations confirm it) that "cancer" in fish is predominantly of the sarcomatous type may suggest some further line of research. At all events the extension of minute tissue investigation to the fishes, with these ideas in mind, cannot fail to be productive—if carried far enough.

There is, of course, the somewhat depressing thought (one which can hardly fail to suggest itself to the biologist) that malignant growth is *a disease of evolution*. The idea, however, is too speculative an one to discuss in the light of our very limited knowledge of comparative pathology.

The Piel Laboratory.

The fish hatching was resumed in the Spring, 1924. The pumping machinery and tanks are now in good working order after the change from gas fuel to electricity. A stock of spawning plaice was obtained from Luce Bay last November and these fish lived well in the tanks. The hatching operations in the Spring of 1924 followed the usual course and the results were quite successful, plaice larvae being liberated as before.

A class for steam trawlers was held in March of 1924, being conducted by Captain Ingham and myself. The men worked well for the duration of the class—three weeks.

A Proposed Fishery Research Association.

Various visitors came to the laboratory. The fishermen's class was seen, as usual, by Mr. Harris, H.M. Inspector of fishery schools. An interesting visitation was that of a party of Fleetwood owners of fishing vessels brought over by Mr. Jas. A. Robertson, the Chairman of Council of the Association of British Fisheries. Various speeches were made, in particular one by Mr. Robertson, strongly urging the formation of a Fishery Research Association under the scheme elaborated by the Department of Scientific and Industrial Research. For this purpose he anticipated that a sum of £50,000 would have to be raised by the Steam Fishing and Subsidiary Industries: if this could be managed (and, given a revival of trade in the country, there ought not to be much difficulty) he expected that the Department would make a grant of £ for £. He hoped that the Research Association would be placed at Fleetwood and would work in co-operation with the Universities of Liverpool and Manchester.

In my opinion the time is now ripe for some project of this kind. An enormous amount of scientific investigation has been made on fishery matters during the last forty years. Of necessity the subjects that have been studied have been almost entirely the life-histories of edible fishes, molluscs, crustacea and the animals and plants associated with these, either as food or as competitors. Along with these matters there has been hydrographical investigation, started with the object of finding out what physical conditions (temperature, salinity of the sea, weather, etc.), affect the abundance of fish. Necessarily there has also been much investigation of problems of purely scientific interest because it has always been impossible to say what scientific results are likely to turn out of practical value and what not. A prominent part of the scientific work of the Committee in the past has also been the investigation of the mussel and cockle beds in the

Lancashire, Cheshire and Welsh districts, in relation to their liability to sewage contamination. Here the Committee (advised by the late R. A. Dawson and Professor Herdman) did really pioneer work, both with regard to research into the natural conditions leading to dangerous pollution of the shell-fish and the measures that might be taken to counteract the pollution by relaying. This work has ceased, partly because of legislation instigated by the Ministry of Health (which has now practically removed control of the shell-fish layings from the fishery authorities) and partly because of the establishment of a bacteriological laboratory and experimental tanks by the Ministry of Agriculture and Fisheries at Conway. It is, of course, undesirable that there should be overlapping and so any future research into these matters that is necessary can be made at Conway.

Fishery research has, in the main, had for its object the attainment of knowledge that will be useful in administrative affairs (restrictions, size-limits, close times, etc., etc.). It is certain that such research will have to be continued in the future—though it is evident that administrative progress has lagged behind the scientific results already obtained: thus the very extensive investigations into the life history of the plaice in the North Sea, carried on for 20 years have not, so far been followed by legislation, though the nature of this legislation was very clearly indicated in the reports of the International Council for Fishery Investigations.

But it is certain that the time has now come to *apply* the results of research in industry. A great amount of knowledge relating to fish as food, fishery by-products and such matters as the preservation of fish by curing and canning now exists. Much is known about marine organisms capable of being used in industry—and not at all utilised so far. Purely scientific research indicates new lines along which such scientific-industrial investigation might proceed. But the

application of scientific results to industry certainly requires a new kind of organised research—a combination of factory and laboratory methods—and the existing working of fisheries institutes does not give us this combination. Some kind of organisation, similar to that of the Cotton Research Association, for instance, seems to be indicated and it is from this point of view that the suggestion made by Mr. Robertson at the meeting at Piel is to be commended to the attention of members of the Committee. There is probably no other British industry in relation to which so much scientific research has been made as that of the sea fisheries and it is now quite certain that ten years of well-planned, adequately supported scientific, industrial investigation would benefit the industry itself—and the nation—in a very material degree.

JAS. JOHNSTONE.

UNIVERSITY OF LIVERPOOL,
July, 1924.

THE PLANKTON IN THE SPAWNING PONDS AT PORT ERIN.

By A. SCOTT.

Two years ago, Professor Johnstone suggested that it might be worth while to supplement the long series of investigations into the plankton of Port Erin and its vicinity by studying the quality and quantity of the plankton organisms occurring in the large ponds attached to the laboratory and the seasonal changes. For this purpose, bi-weekly collections of about fifteen minutes' duration were made with the coarse and fine nets during the whole of 1922 and 1923 and sent to me for examination. The water in the ponds is used to supply the aquarium tanks and the fish hatchery. A certain amount of it is returned to the ponds after circulating through the tanks, etc. The ponds are completely filled up from the sea every twenty-four hours, the in-take pipe being several feet under the surface at high water. Mr. Smith estimates that it takes about a couple of weeks completely to renew the whole of the water.

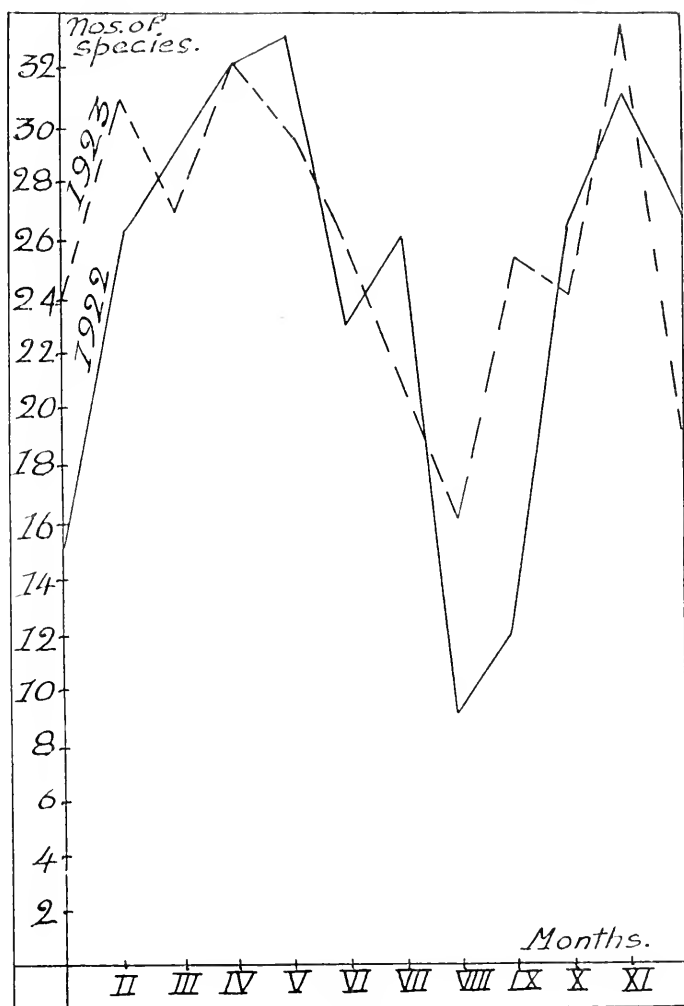
We had very little idea when the investigation was commenced what we would find in the way of plankton, apart from acclimatised species of copepoda belonging to the Harpacticoida and a few other organisms which might be developed in the ponds. We did not expect to find that the plankton, if there was any, would have practically the same well-defined seasonal changes to what we know occurs in the open sea. The depth under the surface of the in-take pipe did not, in our minds, lend itself to a very large introduction of truly surface organisms. We now find from our results that close in-shore there appears to be practically no difference between the surface and bottom plankton and that, with regular pumping, it is fairly certain that the plankton in the

ponds will be very similar in quality and quantity to that in the bay itself. That this must be so is proved by the numbers of young plaice that are found when the ponds are cleaned. These little plaice have hatched in the ponds, fed on the plankton around them and successfully completed their metamorphoses. The shelter of the pond does not prevent the seasonal changes that occur in the open sea nor does it apparently help, to any marked extent, to prolong the life of any of the truly planktonic organisms. A sudden great invasion of huge numbers of one species is just as probable as in the open sea, but it quickly fades away if there is no renewal in the water from the sea. There were two great invasions of species of diatoms in 1923, represented by millions of individuals in the samples taken. One was in the spring and the other in the winter. There was little or no indication at all of their appearance in samples taken a day or two before the huge numbers arrived. Samples taken a few days later revealed that the huge numbers had entirely vanished or had become very reduced. One or two of the plankton organisms in the ponds have apparently become acclimatised and are to be found in almost every haul, but with these exceptions the plankton of the ponds varies in abundance and constitution very much as in the sea. The collections were examined quantitatively to arrive at an estimate of the numbers of individuals present.

Number of Species Identified.

The accompanying Graph I shows the numbers of identified genera and species that occurred in the plankton from month to month in 1922 and 1923. Starting off with fifteen species of phyto- and zooplankton organisms in January, 1922, there was a sudden rise to twenty-six in February and a further increase through March and April to the month of May, when the total reached thirty-three species. This was the maximum for the whole of that year. The number then dropped rapidly, with

the exception of a slight recovery in July, to nine in August. That was the minimum. The increase in the number of species



GRAPH I

during the next three months was quite rapid. A second maximum was reached in November, when the total identified

species of all organisms amounted to thirty-one—two less than the May maximum. A decrease set in and at the end of the year the plankton contained twenty-seven identified organisms.

In 1923, the number of species of organisms started off at twenty-four in January and rose to thirty-one in February, falling in March to twenty-seven, and reaching the spring maximum of thirty-two in April. The decline to the summer minimum was less rapid than in 1922. The lowest point again occurred in August, when sixteen different kinds of plankton organisms were present. With the exception of a decrease of one species in October, the rise to the winter maximum was much the same as in the year previous. The winter maximum in November was represented by thirty-three species—the highest number during the whole year. After November a rapid fall set in, and the year ended with nineteen species. There is thus a spring maximum in April and May, a summer minimum of all kinds of organisms in August, and a winter maximum in November.

The number of species present does not always mean that the number of individuals may be large or small. The maximum of thirty-three species in May, 1922, was represented by a monthly average of nearly 33,000 individuals in the samples, while the maximum of thirty-one in November reached only half that total. The minimum of nine species in August was represented by nearly 18,000 individuals. There was no marked invasion of any kind in 1922, and the monthly average for the year amounted to nearly 18,000 individuals. The lowest number of individuals were found in October, 1922, when thirty-one species were represented by 2,000. A similar number of species in February, 1923, were represented by a monthly average of nearly one-and-a-half millions of individuals, largely made up of a single species of diatom. The spring maximum of thirty-two species in April, 1923, only averaged 60,000 for the whole month. The minimum of fifteen

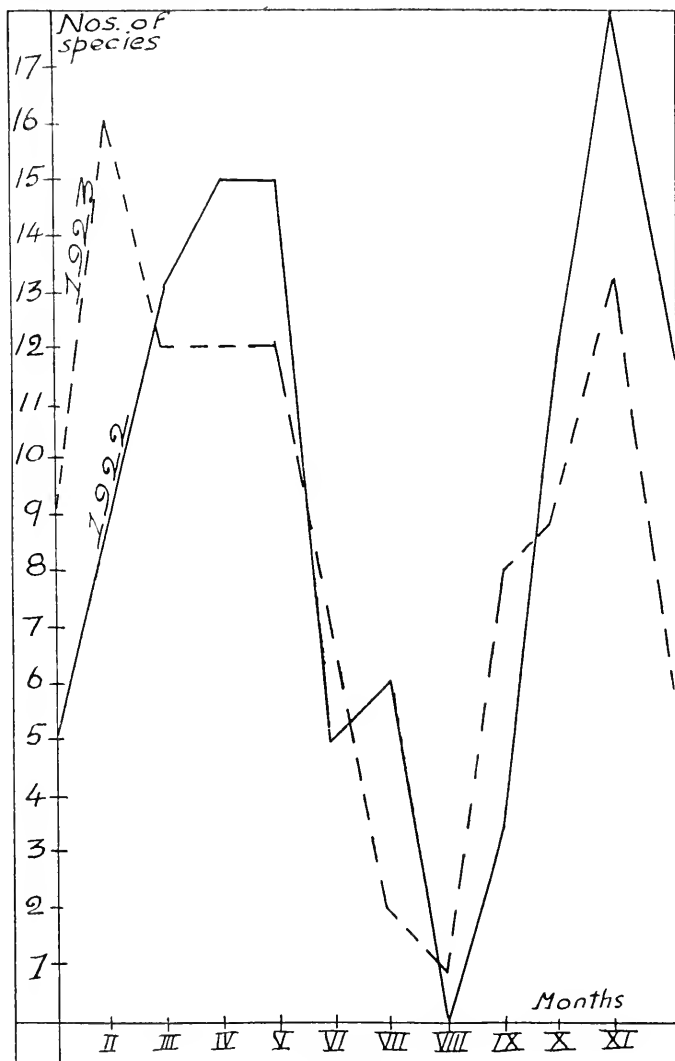
species in August was represented by over 56,000 individuals, which was considerably more than the highest monthly average in 1922. The maximum of thirty-three species for the whole of 1923 was represented by just over 28,000 individuals. The monthly average for the whole year was 193,000. There were three well-marked sudden invasions—two of diatoms and one of the cladoceran *Eradne*.

The Phytoplankton

The accompanying Graph II gives a good idea of the spring and winter maxima and the summer minimum of abundance of the various species of diatoms. The average number of species in January, 1922, was five. A fairly rapid increase set in through the months of February and March to April, when the spring maximum of fifteen species was reached. This number remained constant in May and then fell rapidly to five in June, with a recovery to six in July and then a further decrease in August, when the phytoplankton completely disappeared from the ponds. Three species appeared in September and twelve in October. The highest point, in number of species, during the whole of the two years 1922 and 1923, was attained in November, 1922, when eighteen species belonging to various genera of diatoms were present in the ponds. The number decreased to twelve in December. There was no notable large number of any individual species, and the phytoplankton as a whole was poorly represented. The monthly average of numbers of individuals for the whole of the twelve months was only 3,692. The largest number present in a combined sampling of the coarse and fine nets was just over 22,000 (*Chaetoceras debile*). That occurred on November 28th, and was quite exceptional, as the other combined samples only contained from 30 to 4,000 examples of any one single species.

The phytoplankton in 1923 began with the fairly

high number of nine species and quickly rose to sixteen in February. This was the spring maximum. The numbers fell to twelve in March and remained constant until May, when



GRAPH II

a practically continuous decrease to one species in August set in. The rise towards the winter maximum was almost as rapid as in 1922, but it did not rise so high. The winter maximum was again in November. There were thirteen species compared with eighteen of the previous year. The number decreased to six in December. There were two well-marked invasions in 1923. One in February (the 28th), when nearly five millions of *Skeletonema* were taken by the two nets. This is the first time we have noticed this particular form in the Irish Sea, but it has been recorded from various parts of the channel and round the coast. It was obviously one of those sudden and apparently unaccountable invasions of which there are other examples. There was no indication of *Skeletonema* in the collections taken on February 13th, and by the time the next hauls were made on February 27th the total number of individuals had fallen to 500. There was no trace of it at all five days later. The second marked invasion took place on October 23rd, when over two millions of *Chaetoceras contortum* were taken in the combined catch. This was also a sudden invasion, which fell away just as quickly as the February one, but it lasted in small numbers until the end of November. The year 1923 could be considered a favourable phytoplankton one apart from the two invasions already referred to. The monthly average for the twelve months was 163,729 diatoms. The spring maximum in February, of sixteen species, was made up of an average of one-and-a-quarter millions of diatoms for four combined collections. *Asterionella bleakeyi* was the diatom represented in the summer minimum in August. It had an average of forty-five specimens for four combined collections.

The Zooplankton.

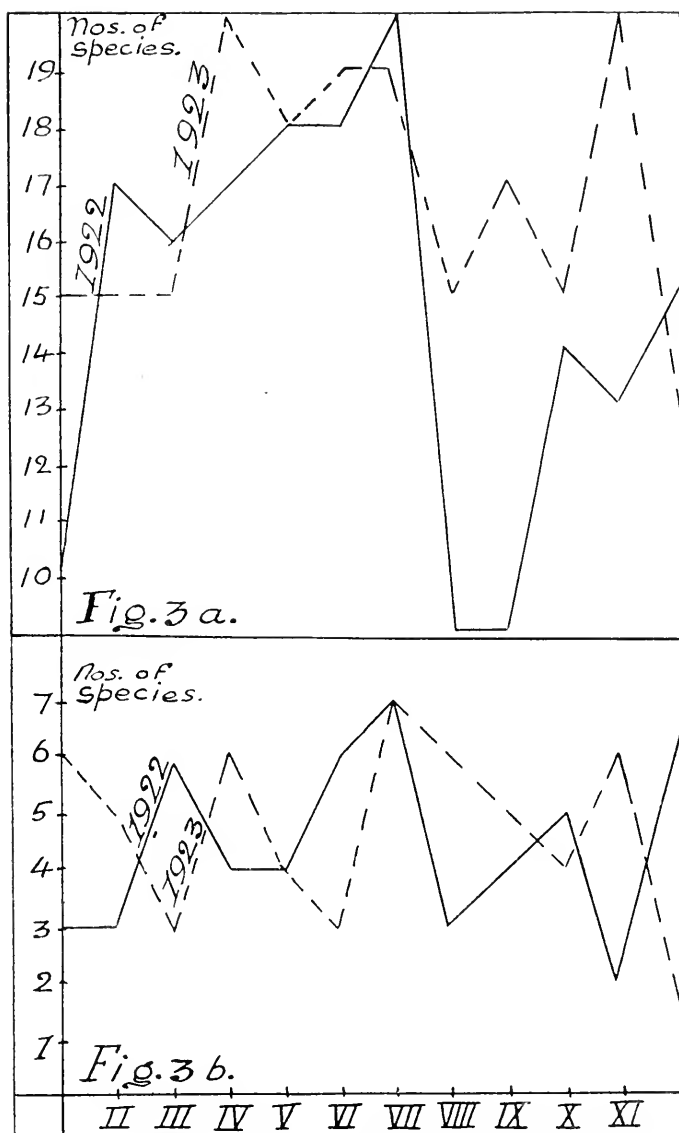
The zooplankton, although showing quite well-marked changes in the course of the year, does not appear to have the same well-defined maxima and minima as are exhibited by

the phytoplankton. The spring maximum of the two years is more definite than the summer minimum or the winter maximum. One point about the zooplankton shown by the Graph IIIa is that the spring or early summer maximum is two months later than the phytoplankton spring maximum. In 1922, the phytoplankton spring maximum was reached in April and the zooplankton one in June. In 1923, the phytoplankton maximum was in February and the zooplankton in April.

In January, 1922, the zooplankton was represented by ten kinds of organisms. The number rose to seventeen in February and dropped to sixteen in March. A rather irregular rise through April, May and June to the maximum of twenty was followed by a rapid decrease to nine in August and September. This was the minimum. The zooplankton then increased to fourteen in October and after decreasing by one in November reached an apparent winter maximum of fifteen in December.

The zooplankton at the beginning of 1923 was evidently influenced to some extent by the numbers at the end of the preceding year, and continued at the same level during January, February and March. This was followed by an increase of five to a spring maximum of twenty in April. Two species disappeared in May, then there was a recovery to nineteen in June and July. The summer minimum was not so well-defined as in the previous year. Although the number fell to fifteen in August, it rose again to seventeen in September, and again fell to fifteen in October. The winter maximum was much better defined than in 1922 and also higher. It occurred in November, and for the second time in 1923 the number of zooplankton organisms was twenty. A considerable decrease followed, and in December only thirteen organisms were present—the lowest during the whole year.

One or two types are rarely absent from the zooplankton. The copepod *Idya furcata* is one of them, and it offers a consider-



GRAPH III

able food supply to young fishes. Females with egg-sacs are to be found in nearly every collection, and the characteristic nauplius is often more abundant than the adult. The nauplii of other copepoda along with the nauplius of barnacles also occur freely. It is quite contrary to our experience to find the nauplii of barnacles amongst the zooplankton in every month of the year. One rarely finds them in the open sea after the early summer months. It is probable that the shelter of the ponds is helpful to reproduction by the adults all the year. Larval Polychaeta and the rotifer *Notholca striata* are also ever present, sometimes in large numbers. The cladocera *Evadne* and *Podon* are mainly summer types and sometimes appear in swarms. On June 18, 1923, over 100,000 *Evadne* were present and formed the bulk of the catch on that date, which amounted to 116,270 individuals representing fifteen different organisms. *Podon* does not become so abundant, but its distribution is apparently more prolonged than *Evadne*. It may last from April to December.

The pelagic copepoda, such as *Calanus* and *Temora* and the other strong swimmers, are well-represented in the plankton of the ponds by seven species. The graph IIIb shows the monthly distribution during the two years. With the exception of the apparent definite maximum in July in both years, the spring, early summer, autumn and winter high and low periods of abundance in 1923 were about a month later than in the previous year. *Acartia* is rarely absent at any time, and is the best represented of the pelagic forms. It often occurs in swarms of thousands of individuals at a time. The combined catch, taken on August 28, 1923, contained twelve different kinds of organisms represented by 210,471 individuals. Of this number 106,660, or more than half the plankton, consisted of *Acartia*. *Pseudocalanus* and *Oithona* are also fairly evenly distributed throughout the year, but they are never at any time abundant.

The pelagic eggs and larvae of various fishes are also found in the plankton from the ponds. The adult plaice spawn in the ponds and the eggs are collected for hatching. Cod eggs are sometimes carried in with the returned water from the aquaria. The eggs of the other fishes are, no doubt, pumped into the ponds along with the water where they eventually hatch. The eggs and larvae are not included in the graphs of all the plankton organisms and the zooplankton as most of them are removed before the samples are preserved.

The following list shows the various phyto- and zooplanktonic organisms identified in the collections from the ponds and also their monthly distribution in 1922 and 1923.

Table of Occurrence of the Organisms Identified.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
<i>Uelosira borreri</i>	★
<i>Ukeletonema costatum</i>	★
<i>Uhalassiosira</i>												
<i>nordenskioldii</i>	★	...	▣	★	▣	...
<i>Uhalassiosira gravida</i>	★	▣ ★	▣ ★	▣	▣	...
<i>Uoscinosira polychorda</i>	★	★	▣	▣
<i>Uauderia borealis</i>	★	★	▣ ★	▣ ★	▣ ★	▣ ★	★	...	★	▣ ★	▣ ★	▣
<i>Uminardia flaccida</i>	★	▣	▣	▣ ★	▣ ★	▣ ★	▣	▣	▣ ★	▣
<i>Uoscinodiscus concinnus</i>	▣ ★	▣ ★	▣ ★	▣ ★	▣ ★	★	▣	▣ ★	▣ ★
<i>radiatus</i>	▣ ★	▣ ★	▣ ★	▣ ★	▣	▣ ★	▣	★	▣ ★	▣ ★
<i>grani</i>	★	▣	▣	▣
<i>Uchizosolenia setigera</i>	▣	...
<i>shrubsolei</i>	★	★	▣ ★	▣	▣	▣ ★	...
<i>stolterfothii</i>	▣	...	▣
<i>Uhaetoceras densum</i>	★	...	▣	...	▣ ★	▣ ★	▣	...
<i>criophilum</i>	★
<i>boreale</i>	▣ ★	★	▣	▣
<i>decipiens</i> ...	★	▣ ★	▣ ★	▣ ★	▣ ★	★	★	▣ ★	▣ ★	▣ ★
<i>teres</i>	★	▣ ★	▣ ★	▣ ★	▣ ★	★	...
<i>contortum</i>	★	★	...
<i>debile</i>	★	▣ ★	▣ ★	▣ ★	▣ ★	★	▣	▣	▣
<i>Utreptotheca thamensis</i>	▣ ★	▣	▣ ★	...
<i>Uiddulphia mobiliensis</i>	▣ ★	▣ ★	▣ ★	▣ ★	▣ ★	▣	▣ ★	▣ ★	▣ ★	▣ ★
<i>sinensis</i>	▣	▣ ★	▣ ★	▣ ★	▣ ★	▣ ★
<i>Upitylium brightwellii</i>	▣ ★	▣	▣ ★	▣	▣ ★	▣ ★	▣

▣ = 1922.

★ = 1923.

Table of Occurrence of the Organisms Identified—*continued*.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
<i>Terionella bleakeleyi</i>	■ ★	■ ★	■ ★	■ ★	■ ★	★	★	★	■ ★	■ ★	■ ★	■ ★
„ <i>japonica</i> ...	■	■	■	■	■	■	■	■	■	■	■	■
„ <i>usoids</i> ...	■	■	■	■	■	■	■	■	■	■	■	■
<i>etiluca</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>ridinium</i> sp.	★	★	★	■ ★	■ ★	■ ★	■	■	■	■	■	■
<i>ratium tripos</i>	■	■ ★	■	■	■ ★	■ ★	■	■	■	■	■	■
„ <i>furca</i>	★	■ ★	■	■	■	■	■	■	■	■	■	■
„ <i>fuscus</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>lychaeta</i> larvae	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★
<i>traria</i> larvae	■	■	■	■	■	■	■	■	■	■	■	■
<i>gitta</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>tolytus</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>tifers</i>	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★
<i>bster</i> larvae	■	■	■	■	■	■	■	■	■	■	■	■
<i>ysis</i> " of Crangon ...	■	■	■	■	■	■	■	■	■	■	■	■
<i>ea</i> of crabs	■	■	■	■	■	■	■	■	■	■	■	■
<i>don</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>adne</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>anus</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>eudocalanus</i>	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★
<i>racalanus</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>pora</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>atropages hamatus</i> ...	■	■	■	■	■	■	■	■	■	■	■	■
<i>artia clausi</i>	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★
<i>thona</i>	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★
<i>terpina</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>za furcata</i>	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★
„ <i>nauplius</i>	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★
<i>pepod nauplii</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>nea cyclops</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>rnacle nauplii</i>	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★	■ ★
„ <i>cypris</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>steropoda</i> larvae	■	■	■	■	■	■	■	■	■	■	■	■
<i>mellibranch</i> larvae ...	■	■	■	■	■	■	■	■	■	■	■	■
<i>kopleura</i>	■	■	■	■	■	■	■	■	■	■	■	■
<i>l</i> eggs	■	■	■	■	■	■	■	■	■	■	■	■
<i>iting</i> eggs	■	■	■	■	■	■	■	■	■	■	■	■
<i>een cod</i> eggs	★	■ ★	■ ★	■ ★	■ ★	■	■	■	■	■	■	■
<i>ekling</i> eggs	■	■	■	■	■	■	■	■	■	■	■	■
<i>ice</i> eggs	■	■	■	■	■	■	■	■	■	■	■	■
<i>b</i> eggs	■	■	■	■	■	■	■	■	■	■	■	■
<i>under</i> eggs	■	■	■	■	■	■	■	■	■	■	■	■
<i>ice</i> larvae	■	■	■	■	■	■	■	■	■	■	■	■
<i>doid</i> larvae	■	■	■	■	■	■	■	■	■	■	■	■

■ = 1922.

★ = 1923.

FOOD OF THE IRISH SEA HERRING IN 1923.

By A. SCOTT.

Samples of the stomach contents of herring caught during the Manx west coast fishery in 1923 were sent for examination by my colleague, Mr. W. Birtwistle. This is the first extensive series of Irish Sea herring we have had to deal with so far. The results are rather different from what we anticipated from our own experience of the food of the herring and from the work done in other areas by other observers, and it will be useful to publish them here along with Mr. Birtwistle's report on the Manx herring.

References are made here and there in the long series of reports on Intensive Study of the Irish Sea Plankton, by Sir William Herdman and myself, to the food in odd samples of stomach contents of herring and mackerel from the northern area of the Irish Sea and from the west coast of Scotland. Some of them are worth mentioning again. The mackerel fishery off the North Lancashire coast in 1913 began about the end of June and lasted until September. The fish were extremely abundant. For about a week they were feeding on Copepoda and the larval stages of some of the higher crustacea. Occasionally the stomach contents consisted of a pure collection of one species of Copepoda (*Temora*). An extensive invasion of the ctenophore *Pleurobrachia* next became conspicuous in the plankton. It continued for fully three weeks and almost every mackerel stomach was filled with *Pleurobrachia*. There were certainly other pelagic organisms present at the same time, such as larval Polychaeta and higher Crustacea, the Amphipod *Hyperia*, Copepods and young Clupeoids. These were caught in the tow-nets along with an abundance of *Pleurobrachia*,

and they were also found occasionally in the stomachs. This is the only instance during the past quarter of a century we have met with *Pleurobrachia* in such abundance during the summer. A similar invasion occurred in December, 1919, when the receding tide left them stranded everywhere along the shore. At that time, sea-perch or bass (*Labrax lupus*) were being taken in the local stake-nets much to the surprise of the fishermen, who consider the fish as only a summer visitor. Almost at the same time, when the mackerel off the North Lancashire coast were feeding on the *Pleurobrachia*, Sir William Herdman was finding that the mackerel caught off Tobermory were feeding almost entirely on the Copepod *Calanus* and the stomachs were crammed full of them. Occasionally, a few larval higher crustacea were also present. Sir William Herdman found that the stomach contents of a single mackerel contained the same amount of *Calanus* as the tow-net caught in five minutes. That was 6,000. The herring caught during the Port Erin fishery in July, 1916, were feeding mainly on *Calanus*. The following year, the Port Erin herring were feeding almost entirely on *Temora*, and late in July the Copepod became so abundant that it appeared as large patches of a red colour on the surface of the sea off Port Erin and around Calf Island. Herring were then being caught in quantity close to the land and even in the bays and creeks.

It is quite clear that the movements of these pelagic fishes, herring and mackerel, are influenced to a very considerable extent by the presence or absence of plankton organisms. It ought to be possible to predict with a fair amount of accuracy whether these fishes will arrive earlier or later than usual, by making adequate observations on the plankton. I have noticed on several occasions, when zoea and megalopa stages of crabs began to be common objects in the plankton of Barrow channel at the end of May that mackerel reached the area off Walney early in June. A poor plankton in Barrow channel in

May and June is frequently followed by a poor mackerel fishery off the North Lancashire coast. It is very probable that temperature and salinity of the sea are important conditions that control the plankton and thus, indirectly, the movements of the shoals of herring and mackerel that visit the Irish Sea. We have generally regarded mackerel to be a much more voracious feeder on the larger plankton organisms than the herring. It feeds upon all the larger organisms it comes across, including several kinds of young fishes. The herring has been looked upon as a more selective feeder, eating mostly Copepoda and the larval stages of higher crustacea, especially in the summer months at any rate.

The result of the examination of the stomach contents sent from the west coast of the Isle of Man indicate that herring, at times, may feed just as voraciously as mackerel on the larger organisms of the plankton. The food of the herring caught during the fishery in June, July and August, 1923, consisted of the few months old stages of fishes, such as rockling, sand-eels, Clupeoids, gurnard, and long rough dab, along with the crustaceans *Meganyctiphanes*, zoea and megalopa stages of crabs, larval pagurids, *Pandalus*, and various Copepoda. In one of his letters, Mr. Birtwistle tells me he found what appeared to be an ordinary domestic house-fly in one of the stomachs, whilst another contained part of a gonad which may have been thrown overboard with the rest of the dejecta when preparing herring for a meal.

The herring very suddenly ceased feeding in the last week of July, and none with full stomachs were again caught till the second week of August. After that date bad weather set in and the fishery practically came to an end. The fishery extended to varying distances from one to six miles off the coast, mostly, however, about two or three miles out between Peel and Bradda Head. Each sample sent usually represented the contents of several stomachs from each day's fishing.

The following are the results of the examination of each sample along with the date and locality of the catch :—

- | | |
|--|---|
| <p>JUNE 14—Off Peel.
 64 young rockling,
 4 zoea and 13 crab megalopas,
 4 larval <i>Pandalus</i>, 2 larval
 Pagurids.</p> | <p>JUNE 15—Off Peel.
 14 <i>Meganyctiphanes</i>.</p> |
| <p>JUNE 20—Off Peel.
 Many <i>Meganyctiphanes</i>,
 1 zoea of crab,
 3 larval <i>Pandalus</i>, 3 larval
 Pagurids,
 12 <i>Calanus</i>.</p> | <p>JUNE 20—Off Port Erin.
 7 young rockling $\frac{3}{4}$-in. long.</p> |
| <p>JUNE 21—Off Peel.
 17 young rockling,
 1 young gurnard,
 1 long rough dab,
 3 zoea and 25 megalopas,
 3 larval <i>Pandalus</i>,
 Many <i>Meganyctiphanes</i>,
 50 <i>Calanus</i>.</p> | <p>JUNE 27—Off Peel.
 Part of a gonad.</p> |
| <p>JULY 7—Series XIV
 8 larval <i>Pandalus</i>,
 4 larval Pagurids.
 Many <i>Calanus</i>,
 60 <i>Temora</i>,
 50 <i>Centropages</i>.</p> | <p>JULY 8—Off Peel.
 3 young Clupeoids,
 Many <i>Meganyctiphanes</i>,
 6 zoea,
 Many <i>Calanus</i>,
 80 <i>Temora</i>,
 60 <i>Centropages</i>.</p> |
| <p>JULY 14—Off Peel.
 18 young Clupeoids,
 Very many <i>Acartia</i>,
 20 <i>Temora</i>, 15 <i>Centropages</i>,
 Many nauplii of Copepoda.</p> | <p>JULY 21—Off Peel.
 2 young rockling,
 1 larval <i>Pandalus</i>,
 Many <i>Calanus</i>.</p> |
| <p>AUGUST 8—Off Contrary Head
 50 young sand-eels,
 12 megalopa of crabs,
 3 <i>Meganyctiphanes</i>,
 20 <i>Calanus</i>,
 1 <i>Caligus rapar</i>.</p> | <p>SEPTEMBER 5—
 Many <i>Meganyctiphanes</i>.</p> |

All the young fishes, with the exception of the long rough dab, were too much digested to determine anything more than the genus to which they belonged. The long rough dab was in good state of preservation and agreed quite well with the figures in the literature. The adult forms of the pelagic crustacea usually possess some character that is not too rapidly affected in the process of digestion.

FISHES :—*Onus* sp. *Trigla* sp. *Clupea* sp. *Ammodytes* sp.
Drepanopsetta platessoïdes.

CRUSTACEA :—Brachyura, zoca and megalopa. Anomala,
Pagurus larvae. Macrura, *Pandalus* larvae. Schizopoda,
Meganyctiphanes norvegica (G. O. Sars) Copepoda, *Calanus*
septrionalis (H. Goodsir), *Centropages hamatus* (Lillj.),
Temora longicornis (O.F.M.), *Acartia clausi* (Giesb),
Caligus rapax, M. Edw., nauplii of various copepoda.

A STUDY OF THE COMPOSITION OF THE MANX
HERRING SHOALS DURING THE SEASON OF 1923.BY
W. C. SMITH

(Port Erin Biological Station).

For three hundred years at least, shoals of herrings have regularly visited the waters of the Irish Sea to the west and south of the Isle of Man, and provided a fishery for fleets operating from Manx Stations during the summer months, May to September.

With the object of gaining some knowledge of the composition of these shoals, samples were taken almost daily throughout the season of 1923, from June to September, and 3,225 fish were examined during the course of the fishery. The daily sample consisted, usually, of 50 fish, and 67 such samples were obtained from the quay at Peel and Port Erin, and immediately worked up for a determination of size, age, sex and gonad condition, the operation being completed within twelve hours of capture. A really representative sample of the run of fish is presented by this regular and frequent examination of the catch, and a fair idea of the class of herring forming the Manx shoals should be gained by a study of the material provided.

Shoals begin to work in to the Manx coast in May, and the abundance increases during June to reach a maximum in July or August, remaining of economic importance until the end of September. Early fish are small in size and number, with the gonads not far advanced in development, but in June and July shoals of larger herrings, with developing roes and milts, approach the coast, and the maximum catches are usually made in August, when most of the fish are "full." September landings contain a large proportion of spent fish,

and this month, nowadays, marks the end of the fishery ; but in former years operations were carried on through October, on the south-east side of the Island, for spawning and spent fish.

The shoals, in the main, consist of fish which will spawn in September-October, and the genital organs show a progressive advance in the state of maturity as the season advances. In May, the bulk of the catch are maturing virgins, or recovering spents, and the organs gradually ripen during June and July until, in August, the majority are " full " fish.

Size.

When the records are studied, it is at once evident that there are two classes of herring landed in the Isle of Man : one, a small fish taken inshore, and the other a larger type from the offshore grounds. The inshore region, where the locally termed " Low Fishery " is conducted, is situated off the western side of the Island, between Peel and the Calf of Man, within six miles of the land. A number of the local boats confined their activities to this locality during the season, and these shoals were well sampled throughout the period June, July, August.

(1) The Inshore Fishery.

It will be seen from Table I that the majority of the fish from this ground were contained in a very short range of size, the dominating frequencies being at 23 and 24 cms. This holds good for the full period, May-August, in this region, and there was no influx, at any time, of large fish. Abundance was maintained until September, and this ground is, apparently, a habitat during the summer months, for shoals of young maturing fish. The accompanying tables of measurements, together with Fig. 1 of Graph I, will serve to show the constant size of the fish of these shoals during the three months June, July, August.

Numbers of fish of different lengths (in cms.) contained in the samples examined during 1923.

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TRANSACTIONS LIVERPOOL BIOLOGICAL SOCIETY.

Months.	10	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Regions.
VI	2	10	43	121	315	246	70	35	8	1	1	Inshore Fishery
VII	...	1	3	7	27	106	233	211	135	64	33	4	2	...	...
VIII	1	1	13	33	92	128	64	34	14	3	...	...	...
IX	11	6	4	3	5	2	3	1	...	
VI-IX	...	1	6	18	83	260	651	591	273	136	60	10	6	1	...	Port Erin Bay
VI	1	2	3	10	8	6	1	...	...	...	...
VII	14	28	23	20	12	3	...	...	...
VI-VII	1	2	17	38	31	26	13	3	...	...	...
VIII	1	1	12	24	36	41	50	49	34	31	6	...	Calf Fishery
IX	1	6	22	18	14	37	46	69	78	9	1	
VIII-IX	1	...	...	1	2	18	46	54	55	87	95	103	109	15	1
IX	1	1	9	11	14	8	4	2	Off Douglas Hd.
VII	4	2	3	4	23	25	26	11	1	2	Off Lambay Island
VIII	6	11	15	25	41	84	70	7	1	
VII-VIII	4	8	14	19	48	66	110	81	8	3	

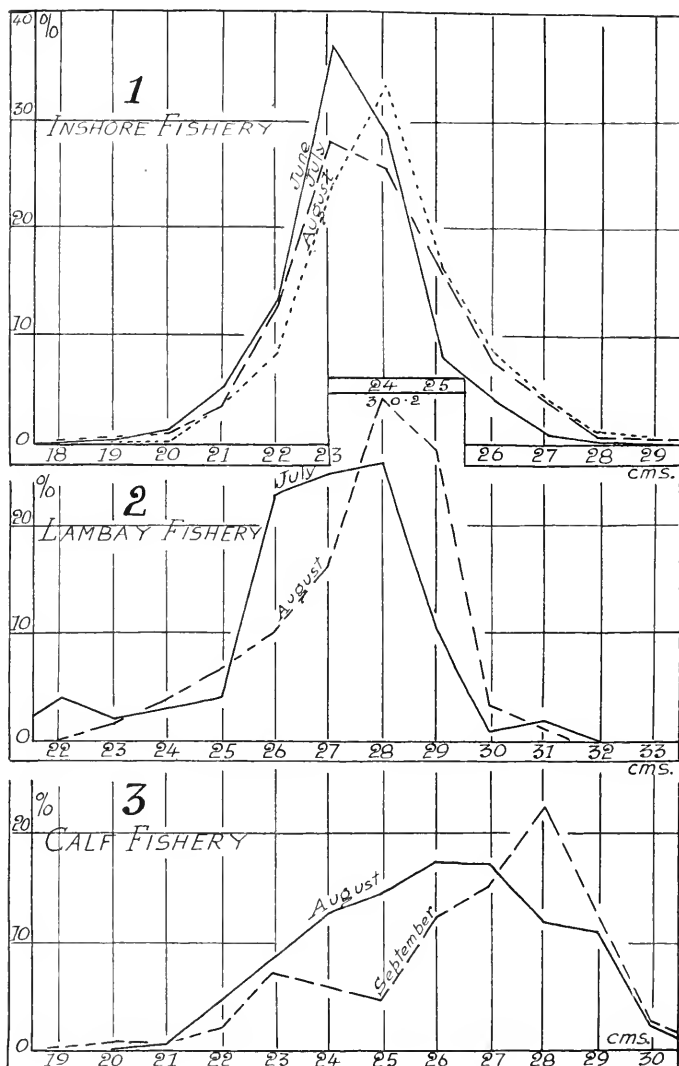
Summary Table.

No. of Fish.	Mean size.	Modal size.	Shortest half-range.	Region.
2,096	23.65	23	23-24	Inshore.
131	24.84	24	24-25	Port Erin Bay.
587	26.50	29	27-29	Calf of Man.
50	25.72	26	25-26	Douglas Head.
361	27.35	28	28-29	Lambay Island.

(2) *The Steam Drifter Fishery.*

A different class of fish was landed towards the end of July by steam-drifters operating a few miles from Lambay Island, which lies off the Irish coast about six miles north of Howth. Few of these herrings were under 26 cms. in length, the majority (73 per cent.) being fairly evenly distributed over the sizes 26, 27 and 28 cms., with fair numbers at 29 cms. (See Table I.) The run was similar in August except that the frequencies at 28 and 29 cms. had appreciably increased at the expense of the 26 and 27 cms. fish. Landings from this ground continued until the end of August, when the shoals worked across the Chammel towards the Isle of Man, and the steam-drifter operations in September were conducted 10-25 miles west-south-west to south-west (Mag.) of the Calf of Man. Fig. 2 of Graph I shows the size of fish off Lambay Island in July and August.

Boats began to work the Calf of Man ground in the second week of August, and continued in this locality until mid-September when the season was brought to a close somewhat early owing, chiefly, to bad weather. The range of sizes in this area was much greater than at Lambay or Inshore, and fish of all lengths between 23 and 29 cms. were well represented in the sample during August, with the greatest number at 26 and 27 cms. (See Table I.) This seems to suggest a region where different shoals meet, and it is significant that the heaviest landings for the whole fishery are usually made from this area during August when most of the fish are "full." Spawning fish are not taken in this locality, and it may be that there is a concentration here before moving on to the spawning ground, in September. The smaller fish were not taken in such quantities during September, and the size curve (Fig. 3 of Graph I) shows a decided peak at 29 cms. More than half the total in this month were spent fish, and the numbers on the ground were dropping considerably.



GRAPH I. Prevalent lengths, in cms., of herrings landed in Manx ports, from the grounds mentioned, during June to September, 1923

(3) *Fishing by Anchored Nets.*

Herrings were caught by anchored nets shot across the mouth of Port Erin Bay, from the middle of May until August. Catches were good in July, but a strong gale from the south-west on the 2nd August drove out the shoals and, with the exception of one good shot on the 22nd August, very few fish were taken subsequently. The run of fish was rather better than that taken by the Peel boats fishing inshore. Peel fish were chiefly 23 cms. in length with very few over 24 cms., whereas the Port Erin Bay sample showed the majority at 24 cms., with 25 and 26 cms. well represented. The gonads were somewhat farther advanced in development and, although the sample was essentially an inshore one, it also contained considerable numbers of larger fish, 25 and 26 cms. in length, which were not present in the catches made by the boats.

Late in September, one or two boats tried the ground which lies off the south-east side of the Isle of Man, where spawning and spent fish are sometimes taken in September and October. They were not very successful and soon gave up the attempt, but a sample of 50 fish was secured from a boat which shot her nets seven miles south by west of Douglas Head, on the 21st September. Most of the fish were in a spent condition, and one was actually spawning. The frequencies were highest at 26 cms., with 84% of the total contained in the range 24-27 cms.

From the foregoing it will be seen that the smallest fish were caught by boats fishing inshore, within six miles of the land, on the western side of the Island, south of Peel, and that a somewhat similar run of fish, though slightly larger, came in to Port Erin Bay. The largest fish were taken off Lambay Island on the Irish side of the Channel, and the Calf of Man ground yielded a mixed sample. Typical sizes for "Low" herrings are 23-24 cms.; Port Erin Bay shows 24 cms. with 25 and 26 cms. in appreciable numbers; Lambay is dominated

by 28 cms. ; but the "Calf" herrings are spread over a greater range of size, and 26, 27, 28 and 29 cms. are well represented, with 23, 24 and 25 cms. also occurring. The "Low" herrings included very few fish over 24 cms. in length, and Lambay catches contained practically nothing under 26 cms. The intermediate size of 25 cms. was, therefore, missing from these shoals but was found in fair numbers in Port Erin Bay in June and July, and off the Calf of Man in August.

Condition.

At the beginning of the season the fish were small, chiefly 23 and 24 cms. in length, and the gonads were at an early stage of development: virgins, maturing virgins and recovering spents constituting 80 per cent. of the catch. The genital organs developed with the season and, in July, their state of maturity had advanced to Stage IV (Hjort's Classification) in the majority of cases, with Stages III and V also well represented. Full fish, at Stage V, greatly predominated in August, and only small numbers of the earlier stages appeared. September herrings were principally "spents," with "full" fish also present in fair quantities. Only one fish with the eggs actually running was observed, and this was taken on the 21st September, seven miles south-by-west of Douglas Head, along with herrings which were for the most part in a "spent" condition.

Table II gives the number and condition of the fish examined, and the graphs show the state of gonads monthly.

Table II. Numbers of fish at each stage of maturity (I to VII) contained in the samples from the various regions (with the totals for all the regions) during the months June–September, 1923.

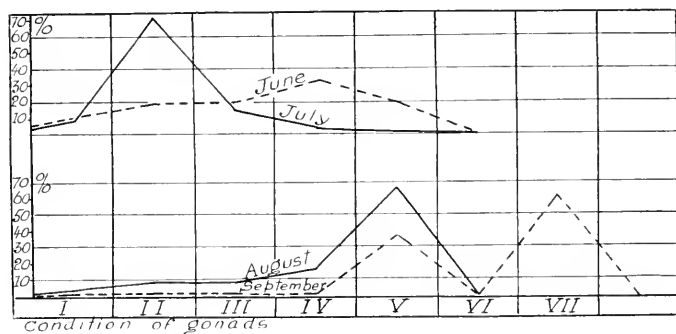
Month.	I	II	III	IV	V	VI	VII	TOTALS	Regions.
June ...	60	515	109	31	2	...	...	717	Inshore.
	2	17	9	3	...	...	...	31	Port Erin Bay.
	62	532	118	34	2	...	...	748	
July ...	103	185	176	253	109	...	...	826	Inshore.
	3	7	19	46	25	...	...	100	Port Erin Bay.
	...	1	1	33	66	...	...	101	Lambay.
	106	193	196	332	200	...	...	1,027	
August	25	60	42	83	153	...	...	363	Inshore.
	8	15	25	53	233	...	...	334	Calf.
	...	1	8	13	238	...	...	260	Lambay.
	33	76	75	149	624	...	...	957	
Sept. ...	...	...	...	...	6	...	29	35	Inshore.
	1	1	2	...	114	...	134	252	Calf.
	...	...	2	1	3	1	43	50	Langness.
	1	1	4	1	123	1	206	337	

NOTE.—The heavy figures represent the totals for all the regions for each of the months, June to September.

Summary Table. Correlation between the condition of the gonads and the months of the fishing season.

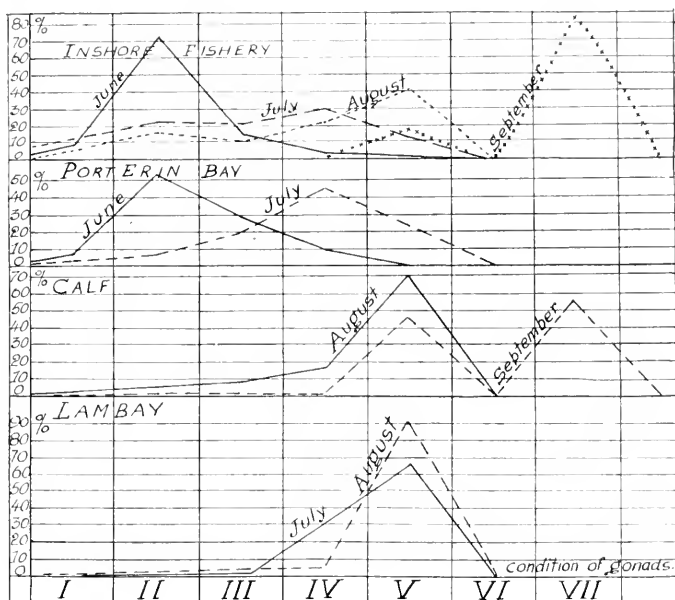
	Virgins and Maturing Spents (I, II).	Filling up (III, IV).	Full and Spawning (V, VI).	Spents (VII).
June	594	152	2	—
July... ..	299	528	200	—
August	109	224	624	—
September	2	5	124	206

The graph represents aggregate figures for the area as a whole, but its application is also relevant to each ground, for when the various localities are examined separately they show the same general conditions. Monthly graphs show the similarity of gonad condition on all grounds at a given time and all of these take the same general lines, the principal divergence being in July, when Lambay shows its maximum at Stage V instead of Stage IV.



GRAPH II. The condition of the gonads in Maux herrings, all grounds combined, landed in June to September, 1923. The vertical scale gives the percentages of fish in each of the groups (Hjort's Scale) represented on the horizontal scale. (In the upper graphs "June" and "July" should be transposed.)

The gonad condition on each ground monthly is represented by the following graphs, which illustrate the progressive development of the generative organs, in each locality, as the season advances.



GRAPH III. The condition of the gonads in Manx herrings landed, from the various grounds mentioned, during the months June to September, 1923. The vertical scale gives the percentages of all the fish in each regional and monthly sample. The horizontal scale gives the condition of the gonads according to Hjort's groups.

The fishing operations of June and July were almost entirely confined to inshore waters, but during the following months, the offshore shoals were well sampled. It is at once evident, from the graphs, that Stage II of gonad condition is the typical state for June herrings but that fish caught in July show a greater range of condition, with the greatest percentage at Stage IV, and with Stages II, III and V about

evenly distributed. This seems to indicate an invasion, during the month, of shoals containing fish with gonads at a rather more advanced state of maturity. August is essentially a "full" month with the great majority of the fish at Stage V of development but with no spawning or spent fish yet appearing. The first "spent" herrings were taken on September 4th, on the "Calf" ground, and this class predominated during the month although "full" fish were still being taken in fair quantities from this region.

The state of maturity of the gonads, therefore, gradually advances with the season from Stage II in May to Stage V in August. Spawning begins early in September and probably extends into October, but fish in this condition were not taken because the spawning grounds were not worked and the boats did not set their nets deep as they do when fishing for this class of herring. The ground off the south-eastern shores of the Isle of Man is known as a spawning area, but the fishery here is intermittent, and operations are not conducted in these waters every year. A mild attempt to exploit this fishery was made in September, but owing chiefly to bad weather no serious effort was made and, as a consequence, spawning fish were not taken during the 1923 fishery.

Virgin Individuals.

Of the total herrings sampled, six per cent. were virgin fish, and they were practically confined to sizes below 25 cms., although three measured 25 cms. and one 26 cms. in length. The percentage of virgin fish in each of these length groups was as follows :—

Length cms. 	21	22	23	24	25	26
Percentage of virgin fish ...	41	16	12	4	0·8	0·3

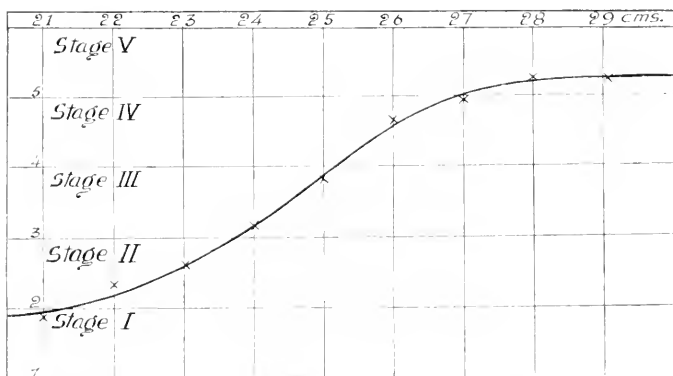
Almost half the 21 cms. fish were virgin individuals, and appreciable numbers of those measuring 22 and 23 cms. were

of that class, but few appeared amongst the 21 cms. group, and above that size their occurrence was negligible. From this it is reasonable to suppose that the Manx summer herring, in the majority of cases, attains the length of 22 cms. during its first spawning season.

Maturity of Gonads in Relation to Size.

When examining the samples it was noticed that the gonads of the larger fish appeared to be at a somewhat later stage of maturity than those of the smaller sizes caught at the same time, and a close study of the records brought out a rather interesting point. Up to 26 cms. in length, the gonads show an advanced state of maturity as the size increases: above this, the state appears to be constant.

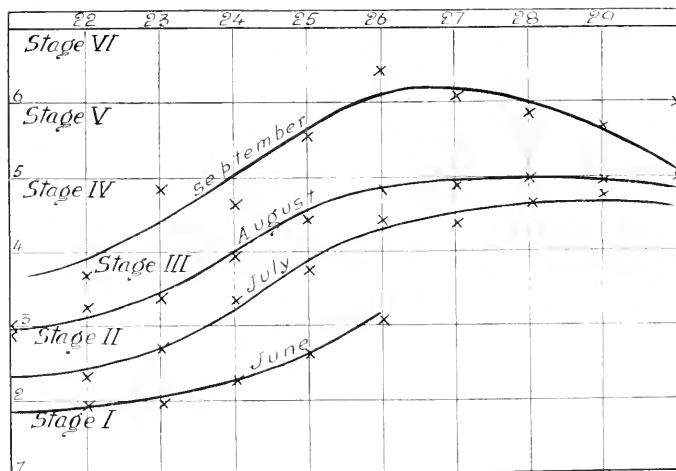
If the number of fish of each cm. length be totalled and the mean state of the gonads for each length worked out and plotted, the following curve results. It will be noticed that the curve rises regularly to 26 cms. and then begins to flatten out.



GRAPH IV. Condition of the gonads in herrings landed in Isle of Man at the same (approximate) time. The vertical arrays show the sizes, and the horizontal arrays show the condition of the gonads, represented, as before, by Hjort's scale of numbers.

The above represents all the samples for the whole period and the whole area and is not an absolutely true reflection of

the conditions, because the various size-groups were not evenly sampled throughout the season. In June, for instance, the smaller herrings which, at that time, were at an early stage of maturity, bulked largely in the catch, and the higher sizes did not attain their maximum until later in the season, when the general state of maturity was further advanced. This, of course, tends to raise the mean state of the larger sizes. The factor of uneven sampling should be eliminated if the months are taken separately, and when this is done it is seen that the rise up to 26 cms. occurs in each month. If, again, graphs are made for each region and each month the same feature persists.



GRAPH V. Condition of the herrings landed from all the grounds in each month during 1923. The vertical arrays show the sizes in cms. and the horizontal arrays show the stage of maturity as represented by Hjort's scale.

This regular advance in the state of maturity as the size increases up to 26 cms. is indicated by the figures in whatever way they are examined, and the fact is worthy of note although the reason may be obscure. It is possible that the majority of the fish under 26 cms. have not spawned before, and that the

process of maturation of the gonads, for the first time, may be slow. If we take 26 cms. as the smallest size at which *all* the fish have previously spawned, then the regular upward movement of the curve through each length from 21 to 26 cms. may be explained by assuming that the proportion of all the fish in a shoal which have already spawned increases as the size increases from 21 to, say, 26 cms.

A study of the figures relating to virgin individuals suggested that 22 cms. was the length at which the majority of the Manx herrings begin to mature, and we assume from this examination of gonads in relation to size, that the majority of fish under 26 cms. have not spawned before. We can, therefore, deduce, with some degree of probability, that the majority of the fish between 21 and 26 cms. will spawn for the first time in their life-histories during the season.

Summary.

From this survey it appears that the early shoals which migrate into inshore waters in May consist of young fish, chiefly 23 and 24 cms. in length, with their gonads in an early stage of first maturity. They remain close in to the land, between Peel and the Calf of Man, until August, when they migrate out to the waters south and west of the Calf of Man, and join the shoals of larger fish which, at this season, gather there from the offshore regions towards the Irish coast. In June and July the inshore shoals receive fresh accessions, and the July arrivals include a number of somewhat larger fish, 25 cms. in length. The gonads of the July fish appear to be rather more mature than those of the herrings which came in June, and, in August, the majority of the fish on the ground are "full" or nearly so, although appreciable numbers of the early stages still appear.

The herrings which came in to Port Erin Bay, although an inshore class, included good quantities of 25 and 26 cms.

fish which were poorly represented in the shoals worked by the boats inshore, and the state of maturity of the gonads was in advance of those of the fish caught by the boats, both in June and July.

Towards the end of July, the large fish over 26 cms. were found off Lambay Island and were caught in this locality throughout August, but there was a north-easterly movement of the shoals towards the Calf of Man as the month progressed, and operations in September were confined to the "Calf" ground. Lambay shoals contained large fish only, and frequencies under 26 cms. were negligible. The July Lambay fish consisted almost entirely of sizes 26, 27, 28 and some 29, with the greatest number at 28 cms., but the frequencies at 26 and 27 cms. dropped considerably during August, and sizes 28 and 29 greatly predominated during this month. Two-thirds of the fish were "full" and one-third were at Stage IV in July, while in August practically the whole catch were "fulls"; so this locality is essentially a habitat for large fish just prior to spawning.

The grounds aforementioned yielded two definite classes of herring: a small fish inshore, grouped round 23 and 24 cms., and a large variety offshore, ranging from 26 to 29 cms., but the "Calf" ground, in August, produced fish of every size, practically all with the gonads "full" or nearly so. The September catches on this ground show a great falling off in the sizes below 27 cms. and a corresponding large increase in the higher groups so that nearly half of the total is contained in the sizes 28 and 29 cms. This points to a large exodus of medium and small fish during September from the waters south and west of the Calf of Man.

To summarise the main features :

Young fish approach the coast in May and remain close to the land for about three months, increasing in abundance

during June and July, and moving to the deeper water off the Calf of Man in August. The older fish come in later, appearing on the Irish side of the Channel in July, and gradually work across to the "Calf" waters and there meet the other shoals, in August. Spawning begins in September and probably continues through October, but no data are available owing to the early close of the fishing operations.

The shoals of large herring come in to the Irish Sea for the purpose of spawning, and do not arrive off the Manx coast until late in the season when they are almost "full." The young fish, however, are present early in May, and it is possible that they have never been out of this region but that they then form spawning shoals for the first time, and join the older fish off the "Calf" in August.

THE AGE, GROWTH AND MATURITY OF IRISH SEA
HERRINGS.

BY W. BIRTWISTLE and H. MABEL LEWIS, B.A.

Introduction.

It was arranged to carry out a more extensive and detailed examination of the Irish Sea herrings during 1923 than had so far been attempted. The area to be covered was so wide that the co-operation of University College, Aberystwyth, was asked and Mr. E. E. Watkin, B.Sc., undertook the examination of samples of herrings taken off Milford, the Smalls and in the whole of Cardigan Bay as far north as Pwllheli. We, at Liverpool, undertook the examination of samples of the herrings caught by boats working from the Manx ports, samples caught by the fish weirs in the Menai Straits and by the anchored nets in Red Wharf Bay, Anglesey, and off the Cumberland and Lancashire coasts. It was hoped that a joint report would be made but this has not been possible.

Our scheme was to take a random sample daily from the landings in the respective areas. Fifty fish for each sample were regarded as a minimum. Length, gonad condition and sex were recorded and scales were collected for age and growth estimation by Einar Lea's well-known methods. These estimations were made the same day, as we have found that scales dealt with whilst fresh and soft are incomparably superior to those which have been dried and dealt with at a later period.

To avoid the expense and inconvenience of purchasing fish for the internal examination for gonad condition, sex and stomach contents, we approached the herring kipperers in the Isle of Man who readily granted us permission to use their gutting yards and observe the fish when opened. We grate-

fully acknowledge the co-operation of Mr. John Keig, of Peel, who gave every facility, and his staff of workers who were so helpful, also that of Messrs. Kelsall, of Peel, and their workers. Further acknowledgments are due to Mr. F. Corris, the admiral of the Manx herring fleet and owner of the nicky "Imen Vorrey," and Mr. John Murray, owner of the Buckie steam drifter "Craig Min," for their kindness in allowing one of us to go to sea in their boats to collect water samples and make general observations on the fishery.

It is a disappointment that the number of our samples in August fell short of expectations and were even worse in September. But this was entirely due to bad weather, which was so unfavourable that most of the Scottish drifters left by the end of the first week of September and only about three local boats remained in commission. As a rule, good fishings are expected during September.

The progress of the gonad development of the Manx herring has been worked up by Mr. W. C. Smith and incorporated with his own data collected at Port Erin. These results are reported on separately in this volume. Mr. J. R. Bruce carried out fat estimations from time to time during the season, based on the age grouping irrespective of length, and his results form another report, published elsewhere. Mr. Andrew Scott carried out the examination of the stomach contents of these herrings and contributes a paper on his results in the present Report.

The Manx fishery was investigated first and the investigations were continued as long as the fishery lasted. This was from June to the end of September. In November the Welsh fishery off Anglesey was investigated. We failed to get any samples from the Cumberland or Lancashire coasts except some very small samples taken by the steam trawlers working between the Isle of Man and Cumberland. All the herrings landed and sampled in the Isle of Man were caught in drift

nets, either by small petrol-engined boats, locally owned, or by steam drifters from various well-known herring fishing centres in England and Scotland. The local boats last year scarcely ever fished more than six miles away from the Manx coast between Peel and Port Erin, except when one or two ventured a little further afield and fished a few miles south-west of the Calf of Man during September. The steam drifters appear about the end of July and fish well over on the Irish side of the Irish Sea about 10 to 20 miles east of Lambay, Rockabill and Carlingford. As the season progresses they gradually work over to the ground some 10 to 25 miles south-west of the Calf, generally during September.

The Lambay herrings during July and August are much bigger than those taken by the local boats in coastal waters at corresponding periods. They range from 26 cms. to 29 cms., as against the 23 cms. to 25 cms. of the coastal herrings, and the homogeneity of the shoal compositions during July and August of each area seems to be well maintained both as regards age and length. During August the Lambay and coastal herrings gradually disappear and at the same time shoals appear in the area south-west of the Calf. These shoals are very mixed and the examination of age, length and maturity seems to indicate a mixing of the herrings from Lambay with the coastal herrings. This is more fully discussed later in this Report.

By the end of September practically the whole of this mixed herring population is spent. This bears out what we already surmise, namely, that south-west of the Calf there is a spawning ground.

The Welsh herrings are either caught in fish weirs or by ordinary drift nets which are anchored close inshore, left overnight and fished at daybreak from large rowing boats. The fish weirs—to give them their local name—are all situated either in the narrow Menai Straits, between Garth Pier and

Menai Bridge, or on the mud flats in the north-eastern entrance to the Straits on both sides. They are walls of wicker work more or less V-shaped, about ten feet high, and placed between high and low water marks. The open ends of the V are about 200 yards apart. The walls are submerged at high water and as the tide ebbs the fish are imprisoned. The wicker work is woven very closely and retains fish of all sorts and sizes. Herrings from 5 cms. to 29 cms. were taken and revealed an interesting mixture of ages and lengths, which is not found in samples taken by drift nets. It is probable that drift net samples do not reveal the true composition of a herring shoal owing to the elimination of the smaller fish. Our programme of work for the present year, 1924, includes a detailed examination of the young stages of herrings under one year old and these fish weirs appear to promise a supply of material, which seems to be present all the year round in varying abundance.

The anchored net fishing in Red Wharf Bay, off Moelfra and Benllech, is carried on more as a form of casual employment than as an organised fishing. It generally starts about mid-October and may continue until the end of January. The older fishermen state that the fishery has been carried on in much the same way as at present, for as long as they can remember. The value of Red Wharf Bay as an autumn herring fishing ground is worthy of more attention and it seems surprising that it has been followed so casually. The Manx inshore boats would seem to be a class of boat well suited for this work and employment seems wanted at this time of the year. Ample security could be found in the Menai Straits, with good docking and railway facilities at Bangor. One objection is the use of Red Wharf Bay as a sheltering ground from the south-west by the coasting vessels and ocean-going vessels waiting for high water to get to Liverpool. In bad weather the bay may be very crowded and thus prevent fishing. This would be so only

on occasions and, even allowing for this, a fairly long season might be expected.

The herrings landed during November, 1923, were of a good appearance, although a fair number were spents. By January the sample was made up entirely of spents, some of which were recovering. Probably this is the extreme duration of the fishery.

Consideration of Individual Areas.

Manx Herrings.

For convenience we have divided these herrings into three distinct groups :—(1) Coastal or “ low ” herring, caught well within the 20 fathom line from Peel to Port Erin ; (2) Lambay herrings, caught East of Lambay Island and Rockabill beyond the 20 fathom line ; and (3) Calf herrings, caught off the south-west of the Isle of Man, beyond the 20 fathom line, within an approximate radius of 25 miles.

(1) *Coastal Herrings* (Table I).

For simplicity our daily results have been summarised at each week-end and these weekly summaries have been re-summarised at the month-end. Fish with more than five rings have been discarded as their numbers are insignificant. It will be observed that throughout the whole season the age composition of these herrings varied only slightly. Fig. 1 shows this very clearly. The graphs are plotted from observed frequencies and are not percentages. The decrease in August and September is due to adverse fishing conditions and not necessarily to the disappearance of the fish. It is interesting to compare the age composition for 1923 with that for 1920 and 1921, although our data for these two years are not extensive. We only compare similar periods.

TABLE I. *Age-Groups of Manx Coastal Herrings examined during the Season June-September, 1923.*

			2 Rings		3 Rings		4 Rings		5 Rings	
Week ending			f.	Mean length	f.	Mean length	f.	Mean length	f.	Mean length
				mm.		mm.		mm.		mm.
June	9	...	15	225	32	231	1	240	...	...
..	16	...	12	234	33	238	5	245	...	...
..	23	...	89	231	274	240	43	251	12	259
..	30	...	75	225	87	237	27	250	3	254
Month of June			191	228	426	238	76	250	15	258
July	7	...	20	226	101	245	19	258	6	269
..	14	...	17	236	90	247	41	255	11	273
..	21	...	48	229	55	241	21	254	1	263
..	28	...	106	231	93	241	18	252	6	266
Month of July			191	230	339	244	99	255	24	270
Aug.	4	...	52	232	53	246	14	258	1	267
..	11	...	34	238	84	248	23	259	7	265
..	18	...	29	230	21	242	2	261	2	270
..	25	...	7	236	10	250	1	242	1	268
Month of Aug.			122	234	168	247	40	258	11	267
Sept.	1	...	...	...	...	...	...	...	...	...
..	8	...	...	...	...	...	...	...	...	...
..	15	...	...	...	...	...	...	...	...	...
..	22	...	2	236	23	253	15	268	5	270
..	29	...	14	238	6	245	2	267	5	272
Month of Sept.			16	238	29	251	17	268	10	271

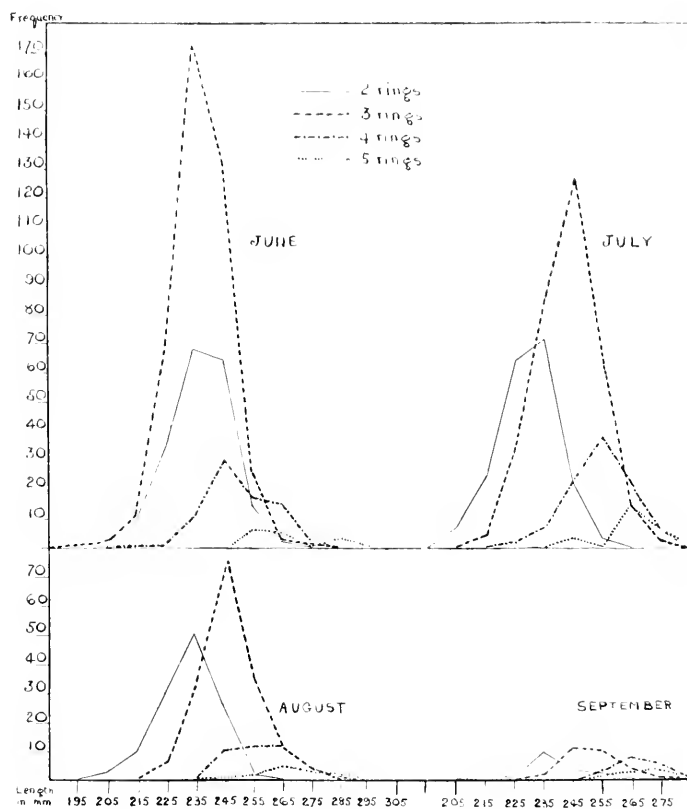


FIG. 1. To show ring group distribution and range of variation in length for each ring group of Manx Coastal Herrings, June to September, 1923.

*Distribution of Age-Groups of Manx Coastal Herrings,
1920, 1921, 1923.*

	2 Rings		3 Rings		4 Rings		5 Rings		Total	Total
	f.	%	f.	%	f.	%	f.	%	f.	%
June, 1920 ...	106	56.38	70	37.23	11	5.85	1	0.53	188	99.99
May, 1921 ...	3	7.69	10	25.64	14	35.90	12	30.77	39	100.00
June, 1923 ...	191	26.94	426	60.17	76	10.73	15	2.11	708	99.99

We have no data for 1922, and May in 1921 is the nearest period for comparison with June. In June, 1920, the 2 and 3-ring fish made up the bulk of the sample, the 2-ring fish predominating. In May, 1921, the sample was fairly evenly composed of 3, 4 and 5-ring fish. The proportion of 2-ring fish is negligible and we are inclined to regard the older fish as spent fish recovering from the previous year's spawning, so that it is doubtful whether they are a true representation of the inshore fishing. In June, 1923, the 3-ring fish predominate.

If we compare the mean length of the various ring groups for 1920, 1921 and 1923, we get the following results:—

Mean Length of the various Age-Groups of Manx Coastal Herrings in 1920, 1921, 1923.

	2 Rings		3 Rings		4 Rings		5 Rings	
	f.	Mean length mm.	f.	Mean length mm.	f.	Mean length mm.	f.	Mean length mm.
June, 1920 ...	106	232	69	234	11	247	1	225
May, 1921 ...	3	253	10	251	14	263	12	264
June, 1923 ...	191	228	426	238	76	250	15	258

June, 1920, and June, 1923, agree very closely in regard to the mean length of each ring group, but May, 1921, is considerably higher than either, thus lending further support to our surmise that the herrings of this sample are a different

stock from the usual coastal herrings. We are not able to investigate further these differences owing to press of time.

Comparing the stages of maturity during these periods in 1920, 1921 and 1923, we find the following uniformity :—

Condition of maturity of the various Age-Groups of Manx Coastal Herrings in 1920, 1921, 1923.

		2 Rings		3 Rings		4 Rings		5 Rings	
		f.	Mean Stage of maturity	f.	Mean stage of maturity	f.	Mean stage of maturity	f.	Mean stage of maturity
June, 1920 ...	105		I-II	68	I II	11	II	1	II
May, 1921 ...	3		II	19	II	14	II	12	II
June, 1923 ...	93		II	242	II	53	II	12	III

It should be borne in mind that for 2 and 3-ring fish, Stage II is probably a virgin condition, but for fish with more than 3 rings it is a recovery from Stage VII.

These data and comparisons merely serve to show in a general way the main features of the Manx coastal herring shoals at the beginning of the season, namely, that they are mainly made up of small, young, immature herrings which will spawn towards the end of the season. They may be occasionally mixed with older herrings recovering from a previous year's spawning.

(2) *Lambay herrings* (Table II).

A superficial examination of a sample of herrings from this area is sufficient to indicate a difference from Manx coastal herrings. We have regarded all our fish as being landed in August although one sample was landed on July 27th and another on September 1st. This is to avoid splitting up

the data. Fish with more than 7 rings have been discarded from our summaries mainly on account of the uncertainty in their classification.

TABLE II. *Age-Groups of Lambay Herrings examined during the season July-September, 1923.*

Week ending					2 Rings		3 Rings		4 Rings	
					f.	Mean length	f.	Mean length	f.	Mean length
						mm.		mm.		mm.
July	28	...	...	...	2	234	3	269	11	266
Aug.	4	...	...	...	9	241	15	257	26	272
"	11	...	...	...	...	...	1	241	1	262
"	18	...	...	...	2	248	6	253	11	276
"	25	...	...	...	1	238	1	285	12	271
Sept.	1	...	...	...	9	245	2	257	6	274
Whole period					23	243	28	258	67	271

Week ending					5 Rings		6 Rings		7 Rings	
					f.	Mean length	f.	Mean length	f.	Mean length
						mm.		mm.		mm.
July	28	...	...	...	10	278	4	276	10	284
Aug.	4	...	...	...	10	278	5	286	5	290
"	11	...	...	...	1	291	6	291	6	292
"	18	...	...	...	8	282	11	291	4	286
"	25	...	...	...	5	284	10	286	14	292
Sept.	1	...	...	...	5	283	10	285	9	286
Whole period					39	281	46	287	48	289

This table shows the age composition and mean length of the respective ring groups. The two and three rings are not so prominent as in the Manx coastal herrings, but a markedly greater abundance of fish with more rings is seen which are fairly evenly distributed. They are mostly full fish in Stage IV or V. We have no adequate previous data with which we can

compare this year's samples. The following table shows the relationship of age composition, mean length and maturity :—

Age Composition, Mean Length and Maturity of the various Age-Groups of Lambay Herrings during August, 1923.

			2 Rings		3 Rings		4 Rings		5 Rings	
			f. %		f. %		f. %		f. %	
Age Composition	...	23	7.82	28	9.5	67	22.79	39	13.27	
Mean Length	...	23	243	28	258	67	271	39	281	
Mean Maturity	...	22	IV	28	IV-V	67	V	39	V	

			6 Rings		7 Rings		Over 7 Rings	
			f. %		f. %		f. %	
Age Composition	...	...	46	15.65	48	16.33	43	16.63
Mean Length	...	...	46	287	48	289	43	293
Mean Maturity	...	...	46	V	48	V	43	V

This particular class of herring is well known to the fishermen. Their definite periodic appearance in this locality strongly inclines us to the opinion that they are immigrants coming into the Irish Sea, probably through the St. George's Channel from the south-west before spawning.

(3) *Calf Fishing Ground Herrings* (Table III).

When fishing is carried on in this area it generally marks the last stage of the Manx herring fishery. There is a varied assortment of fish of all ages, sizes and stages of maturity. One day the sample may reveal young fish with two and three rings, perhaps ranging from Stage III to Stage V. A fortnight later would show older fish with from four to seven rings, ranging from Stage V to Stage VII, and finally, towards the end of September, practically all fish landed from here would be spents.

TABLE III. *Age-Groups of Herrings from the Calf Fishing Ground examined during the season August-September, 1923.*

Week ending					2 Rings		3 Rings		4 Rings	
					f.	Mean length	f.	Mean length	f.	Mean length
August 11	...	...	...	...	10	mm. 234	20	mm. 256	15	mm. 273
" 18	...	...	...	...	14	243	36	256	37	269
" 25	...	...	...	...	21	234	25	253	20	267
Month of August	...	...	...	...	45	237	81	255	72	269
September 1	...	...	...	...	34	237	26	251	7	264
" 8	...	...	...	...	12	236	22	253	17	277
" 15	...	...	...	...	6	240	17	260	42	275
Month of September	...	...	...	...	52	237	65	254	66	274
Week ending					5 Rings		6 Rings		7 Rings	
					f.	Mean length	f.	Mean length	f.	Mean length
August 11	...	...	...	...	4	mm. 272	1	mm. 295	...	...
" 18	...	...	...	...	29	278	21	290	10	292
" 25	...	...	...	...	2	281	5	297	2	281
Month of August	...	...	...	...	35	278	27	292	12	290
September 1	...	...	...	...	2	274	...	...	...	...
" 8	...	...	...	...	8	290	7	293	2	296
" 15	...	...	...	...	31	286	24	291	16	294
Month of September	...	...	...	...	41	286	31	291	18	295

Table III shows the age group composition of the fish taken in August and September and the frequency and mean length for each individual ring group. In previous years the age composition seems to have been fairly consistently made up of older fish than the coastal shoals, but in 1923 the 2 and 3-ring fish were more numerous than usual. The apparent fewness of the 5-ring fish is unexplained.

Distribution of Age-Groups in the years 1920, 1922, 1923.

Calf				2 Rings		3 Rings		4 Rings		5 Rings	
				f.	%	f.	%	f.	%	f.	%
September, 1920	...	...	...	14	5.91	13	5.49	50	21.10	76	32.07
„ 1922	...	...	...	5	8.06	6	9.68	10	16.13	16	25.81
„ 1923	...	...	...	52	17.93	65	22.41	66	22.76	41	14.14

Calf				6 Rings		7 Rings		Over 7 Rings	
				f.	%	f.	%	f.	%
September, 1920	...	...	...	53	22.36	18	7.59	13	5.49
„ 1922	...	...	...	11	17.74	7	11.29	7	11.29
„ 1923	...	...	...	31	10.69	18	6.21	17	5.86

Comparing the mean length of the respective ring groups year by year we are not able to distinguish any important differences if errors of sampling are considered. The backward state of maturity of the 1923 2-ring fish is discussed later.

Age and Length of Calf Fishing Ground Herrings in 1920, 1922, 1923.

				2 Rings		3 Rings		4 Rings		5 Rings	
				f.	Mean length	f.	Mean length	f.	Mean length	f.	Mean length
September, 1920	...	...	...	14	mm. 246	13	mm. 265	50	mm. 271	76	mm. 277
„ 1922	...	...	...	5	236	6	262	10	273	16	282
„ 1923	...	...	...	52	237	65	254	66	274	41	286

				6 Rings		7 Rings		Over 7 Rings	
				f.	Mean length	f.	Mean length	f.	Mean length
September, 1920	...	...	...	53	mm. 278	18	mm. 280	13	mm. 282
„ 1922	...	...	...	11	288	7	290	7	289
„ 1923	...	...	...	31	291	18	295	17	294

Age and Condition of maturity of Calf Fishing Ground Herrings in 1920, 1922, 1923.

	2 Rings		3 Rings		4 Rings		5 Rings	
	f.	Mean Stage of Maturity	f.	Mean Stage of Maturity	f.	Mean Stage of Maturity	f.	Mean Stage of Maturity
Sept., 1920 ...	14	V	13	V	50	V	76	V
„ 1922 ...	5	V	6	V-VII	10	V-VII	15	V-VII
„ 1923 ...	32	III-IV	43	V-VII	66	V-VII	41	V-VII
			6 Rings		7 Rings		Over 7 Rings	
			f.	Mean Stage of Maturity	f.	Mean Stage of Maturity	f.	Mean Stage of Maturity
Sept., 1920 ...	...	...	53	V	18	V	13	V
„ 1922 ...	...	...	11	V-VII	7	V-VII	7	V-VII
„ 1923 ...	...	...	30	V-VII	18	V-VII	17	V-VII

Welsh Herrings (Table IV).

As the methods of catching herrings here are so widely different, we have kept samples caught by the different methods apart, and have classified as Penrhyn herrings those which have been caught in the fish weirs in the Straits, and as Moelfra herrings those which were caught in the anchored drift nets in Red Wharf Bay.

The relatively large numbers of smaller and younger fish caught along with the larger and older fish in fish weirs is interesting. The limit of smallness of herrings taken by the ordinary 4-inch mesh drift net seems to be about 20 cms. to 21 cms. Thus the presence of fish with less than two rings would not be revealed, and probably all our samples taken by

drift nets are not true representations of the composition of the coastal herring shoals. This seems to be borne out by the examination of samples sent in by the steam trawlers.

Referring to our table and allowing for the differences mentioned, these fish are similar to those herring which made their appearance off the Calf of Man in September.

TABLE IV. *Age-Groups of Welsh Herrings caught during November, 1923.*

November, 1923				0 Rings		1 Ring		2 Rings		3 Rings	
				f.	Mean length	f.	Mean length	f.	Mean length	f.	Mean length
Penrhyn	...	...	42	mm.	115	43	mm.	35	mm.	33	mm.
Moelfra	...	...	...	...	...	...	...	24	243	47	255
November, 1923				4 Rings		5 Rings		6 Rings		7 Rings	
				f.	Mean length	f.	Mean length	f.	Mean length	f.	Mean length
Penrhyn	...	...	58	mm.	258	40	mm.	16	mm.	10	mm.
Moelfra	...	...	49	261	41	277	13	283	18	282	283

The mean maturity and age composition of these herrings seem to run as follows:—

Condition of Maturity and Age-Groups in Welsh Herrings,
1923. % frequencies.

	0 Rings		1 Ring		2 Rings		3 Rings		4 Rings	
	f.		f.		f.		f.		f.	
PENRHYN—										
Age Composition ...	42	14.84	43	15.19	35	12.37	33	11.66	58	20.49
Maturity, Mean Stage ...	42	I	43	I	20	V	28	V	53	V
MOELFRA—										
Age Composition ...	...	...	...	...	24	12.18	47	23.86	49	24.87
Maturity, Mean Stage ...	...	...	...	...	24	V	47	V	48	V-VII
					5 Rings		6 Rings		7 Rings	
					f.		f.		f.	
PENRHYN—										
Age Composition ...	...	...	40	14.13	16	5.65	10	3.53	6	2.12
Maturity, Mean Stage ...	...	...	34	V	16	V	10	V-VII	6	V
MOELFRA—										
Age Composition ...	...	...	41	20.81	13	6.60	18	9.14	5	2.51
Maturity, Mean Stage ...	...	...	41	V-VII	13	V-VII	18	V-VII	5	VII

This seems to indicate the presence of spawning grounds in the vicinity, probably a continuation of the ground south and south-west of the Isle of Man which was yielding fish in a similar stage of maturity and of a similar age composition, a month previously.

Comparison of the various areas investigated.

The Manx coastal herrings are a consistent assortment of young herrings, mostly 2 and 3-ring fish, with an addition of a few 4 and 5-ring fish, whilst Lambay herrings are an assortment of older fish mostly with 1 to 7 rings. Herrings from the Calf seem to be a mixture: the result of the migration from the Lambay deep water, on the one hand, and the Manx coastal waters, on the other.

The Welsh herrings from Moelfra, caught in drift nets during November, seem to resemble the mixed herrings from the Calf and are, probably, the herrings of this shoal which were backward in their state of maturity in September. The table (p. 151) will show this, and we believe we can explain the reason for this later in this paper.

Now if we had two distinct classes of herrings, the age, length and maturity of one being much greater than those of the other, and if we were to mix them, the result would be something which is unlike either. This seems to be the case of the Calf herrings, as will be seen by a reference to the following tables. We have lumped our Manx coastal data for all the months. It may be urged that this will give a lower mean length, owing to the fish in June and July not having attained their full length. Actually, however, for reasons we give later, this objection is unimportant.

A Comparison of the Age-Groups of the Herrings from the various Areas during the year 1923.

				2 Rings		3 Rings		4 Rings	
				f.	Mean length	f.	Mean length	f.	Mean length
					mm.		mm.		mm.
Sept.	Coastal	...	...	520	230	962	242	232	255
Aug.	Lambay	...	...	23	243	28	258	67	271
"	Calf	...	...	97	237	146	255	138	271
Nov.	Welsh	...	...	24	243	47	255	49	261

				5 Rings		6 Rings		7 Rings.	
				f.	Mean length	f.	Mean length	f.	Mean length
					mm.		mm.		mm.
Sept.	Coastal	...	...	60	266	...	...	...	...
Aug.	Lambay	...	...	39	281	46	287	48	289
"	Calf	...	...	76	282	58	291	30	293
Nov.	Welsh	...	...	41	277	13	283	18	282

A similar Comparison but showing the percentage frequencies.

				2 Rings		3 Rings		4 Rings		5 Rings	
				f.	%	f.	%	f.	%	f.	%
June	} Coastal	...	...	520	28.92	962	53.50	232	12.90	60	3.31
July		...	...	...	...	...	...	...	...	...	...
Aug.		...	...	23	7.82	28	9.52	67	22.79	39	13.27
Sept.		...	...	...	...	...	...	...	...	...	...
Aug.	} Calf	...	...	97	17.05	146	25.66	138	24.25	76	13.36
Sept.		...	...	...	...	...	...	...	...	...	...
Nov.	Welsh	...	...	24	12.18	47	23.86	49	24.87	41	20.81
				6 Rings		7 Rings		Over 7 Rings			
				f.	%	f.	%	f.	%		
June	} Coastal	...	...	...	...	...	...	24	1.33		
July		...	...	...	...	...	...	...	...
Aug.		...	...	...	...	46	15.65	48	16.33	43	14.63
Sept.		...	...	...	...	...	...	...	...
Aug.	} Calf	...	...	...	...	58	10.19	30	5.27	24	4.22
Sept.		...	...	...	...	...	...	...	...
Nov.	Welsh	...	...	...	...	13	6.60	18	9.14	5	2.54

A similar Comparison, taking into account the conditions of Maturity.

Area			Month	2 Rings	3 Rings	4 Rings	5 Rings	6 Rings	7 Rings
Manx Coastal	...	August	...	III	IV	IV-V	V	...	...
Calf	...	"	...	III-IV	IV-V	V	V	V	V
Lambay	...	"	...	IV	IV-V	V	V	V	V
Manx Coastal	...	September	...	V-VII	VII	VII	VII	...	...
Calf	...	"	...	III-IV	V-VII	V-VII	V-VII	V-VII	V-VII
Welsh—Penrhyn	...	November	...	V	V	V	V	V	V-VII
" Moelfra	...	"	...	V	V	V-VII	V-VII	V-VII	V-VII

It is difficult to explain the sudden change in the 2 and 3-ring Manx coastal herrings from a mean Stage of III and IV, respectively, in August, to VII in September, but the method

of indicating the maturity as a mean stage only may account for this, as the variation may extend from those in Stage I to those in Stage V and be a mean III. This mean condition is only approximate, and we must expect to find those in Stage V suddenly appearing as spents (VII). We might point out that the area seven miles south by west of Douglas, from which our 2 and 3-ring coastal herrings were taken, is an area generally frequented by spawning fish at this time of the year and may be considered an extension of the Calf grounds.

The other main features revealed by this table, in August, are (1) 2 and 3-ring coastal fish are *on an average* less advanced than the Lambay fish; (2) Calf herrings of similar age fall between the two; (3) Higher ring groups show no important variations.

In September, off the Calf, the 2-ring fish range from Stage III to Stage VII. The bulk of these are probably Manx coastal herrings, the spents being the more advanced members of a range of variation in maturity which, as we have seen, is wide. There is no reason, however, why some Lambay 2-ring fish should not be mixed with them. But our sampling of Lambay herrings only reveals a small proportion of 2-ring fish which are probably from the coastal shoals of young herrings which are found along the Irish coast. The other higher groups do not vary.

By November, off the Welsh coast, we find all fish in much the same mean condition, ranging from Stage V to Stage VII, the older fish tending toward the more advanced stage.

From these results we are inclined to think that the difference in attaining full maturity varies most in 2 and 3-ring fish and that, on the whole, their progression is slower than that of older fish.

As a result of the examination of the scales we noticed that where the first year's growth of the fish (calculated by

Lea's method) was relatively large, the fish was generally longer than one with a much smaller first year's growth, although both large and small fish showed the same number of rings. Tables V and Figs. 2-11 expand this observation : the tables are constructed as follows :—

The data are arranged according to regions and months and then in "ring-groups," that is herrings with 2, 3, etc., rings on the scales. The measurements are : —

- " t_1 " = the calculated length of the fish at the moment when the first winter ring has been completed. This measurement is based on the assumption that the growth of the fish is proportional to the growth of the scale and that growth ceases, for the season, when a winter ring is laid down.
- " T " = the total measured length of the herring from the tip of the snout to the end of the dorsal lobe of the tail fin, the latter being extended in line with the body.

The dimension " t_1 " being calculated from the measurement of the scale the groups in the first columns are formed, that is, for instance, 70-80, 80-90, etc. (millimetres), 75, 85, etc., being taken as the central points of the " t_1 " groups. On the same horizontal arrays are the " T 's" of the same herrings and the " f 's," that is, the number of fish in each group. On the same horizontal arrays are the mean stages of maturity in each group. The fractions, for instance, "I-75," are arbitrary estimates of the mean condition of the gonads, meaning in this case between I and II, but nearer to II.

These figs. (pp. 159-168) and tables (see Tables V, pp. 169-180) reveal very clearly that the smaller the t_1 , the smaller the mean T ; and, further, the smaller the t_1 , the less advanced in maturity is the herring. We had often noticed when handling herrings that, although they were the same age, yet the differences in length were very noticeable. Our previous table

of comparisons of mean stages of maturity do not reveal clearly enough the correlation between maturity and length.

Although cases of herrings spawning in the Irish Sea, off the Isle of Man, in February and March are not unknown, they are unusual. We are not able to find any definite bimodal grouping as with North Sea herrings, where spring spawned herrings are present, although our data tends to show a grouping round about 100 mm. and, again, about 130 mm. as a first year's growth. The spawning period in the Irish Sea is very extended—from September to December—four months. The t_1 of our herrings varies from 70 mm. to 150 mm. as a rule, and we are of the opinion that this wide variation is due to the above fact, and we venture the following hypotheses :—

(1) That Irish Sea herrings are all autumn spawned.

(2) That herrings spawned in the very early autumn will show a greater mean length and a more advanced mean stage of maturity than herrings spawned in the late autumn.

We have not been able to trace for what length of time this superiority of length is maintained or when the attainment of maturity becomes uniform, but we are inclined to think that early and late spawned fish are recognisable in the 5-ring group.

Summer Growth.

Referring to Table I (p. 141) it will be seen that there is a gradual increase in the mean length of the Manx herrings for each ring group as the season progresses. From the end of June to the end of September the 2-ring fish have grown 1 cm., the 3-ring fish 1·3 cm., the 4-ring fish 1·8 cm. and the 5-ring fish 1·3 cm. by *very small* increments.

An interesting point appears if we examine the following table of the mean *observed* monthly growth increments compared with the mean *calculated* monthly growths. The observed mean increments are generally higher than the calculated mean increments, but there does not seem to be any very

definite correlation between the fluctuations. Without entering into any discussion as to why they differ, the fact remains that they agree in their smallness—only small fractions of a centimetre. This suggests one important point and it is this, that by the end of June all these fish had made their main annual growth and that after then growth became very slow, probably ceasing by September. The investigation of growth before June is a desirable piece of work and its correlation with the spring plankton maximum. The chief difficulty would be to secure herrings.

Comparison of observed and calculated mean monthly increments in length of Manx coastal Herrings, from June to September, 1923.

Month		2 Rings		3 Rings		4 Rings		5 Rings	
		f.	cms.	f.	cms.	f.	cms.	f.	cms.
June ...	Calculated increment	119	+2.65	265	+1.72	62	+1.27	12	+0.85
	Observed ..	—	...	...	...	...	...	...	...
July ...	Calculated increment	163	+0.29	286	+0.35	77	+0.01	19	+0.04
	Observed ..	191	+0.20	339	+0.60	99	+0.50	24	+1.20
Aug. ...	Calculated increment	110	+0.26	156	+0.04	40	+0.07	11	+0.21
	Observed ..	122	+0.40	168	+0.30	40	+0.30	11	—0.30
Sept. ...	Calculated increment	16	+0.18	29	+0.37	17	—0.26	10	—0.25
	Observed ..	16	+0.40	29	+0.40	17	+1.00	10	+0.40

With three exceptions all increments are positive and are indicated by the plus sign. The calculated increment of the 4 and 5-ring fish in September and of the observed increment of the 5-ring fish in August are negative and are indicated by the minus sign. As these increments are so small, we do not see any real objection to lumping the whole of the Manx coastal data where required for comparison.

Table VI (pp. 181-182) shows the mean calculated yearly

growths of the Manx coastal, Lambay, Calf and Welsh herrings. We are inclined to explain the differences in the first year's growth between the respective areas as being due to the time when, in the autumn, the herring was spawned and not necessarily the place where, with considerations of local influences. Probably if we had some more exact method of indicating gonad development we should find a much closer correlation between t_1 and stage of maturity, than is indicated by a comparison of this table and the table in the text on page 153 where the stages of maturity of herrings from the different localities are compared. Hjort's grading of gonad condition is after all only approximate and unless we have abundant data, errors in estimating stages of maturity may be important since we think it absolutely essential to take into account the gonad development whenever we deal with the calculated first year's growth of a herring.

Figures 2-11 are graphical representations of the mean lengths, T , and mean stages of maturity (broken lines) in relation to the calculated first year's growth, t_1 .

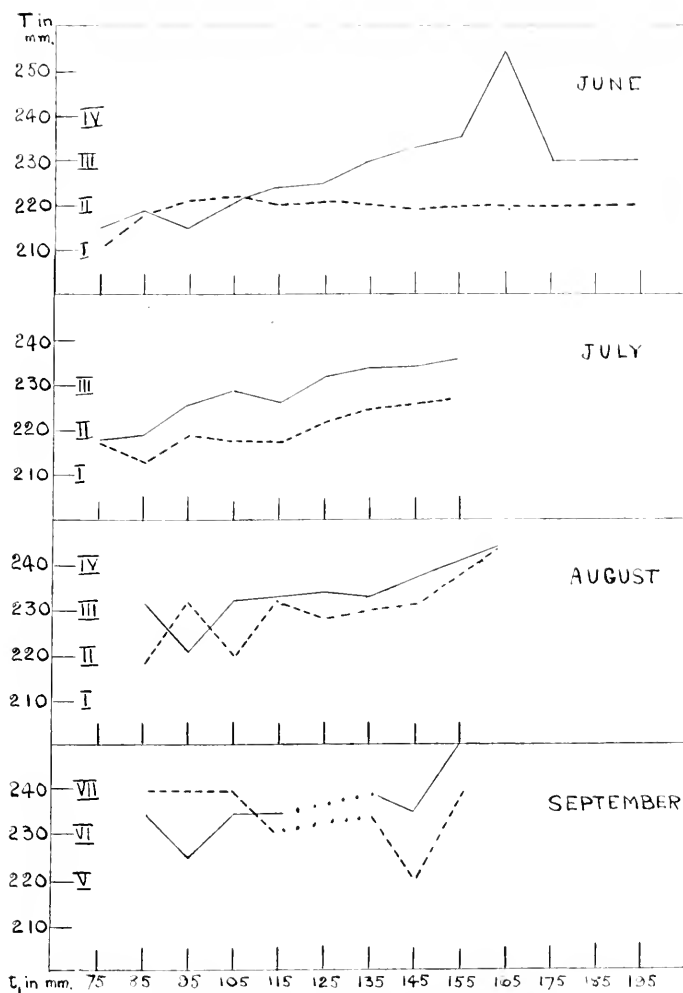


FIG. 2.—Manx Coastal 2-Ring Herrings.

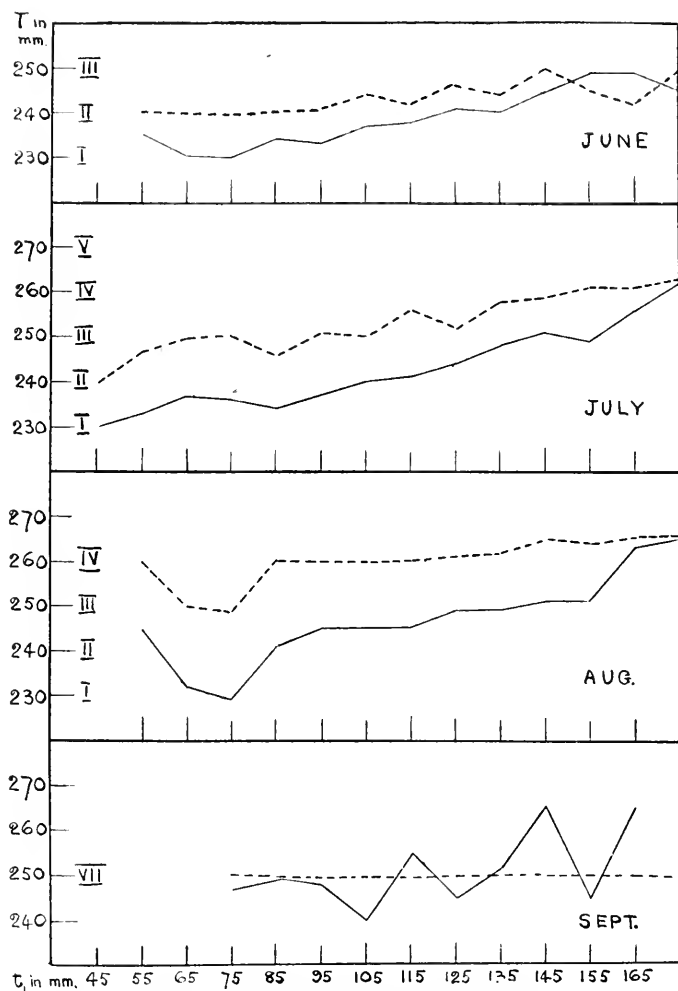


FIG. 3.—Manx Coastal 3-Ring Herrings.

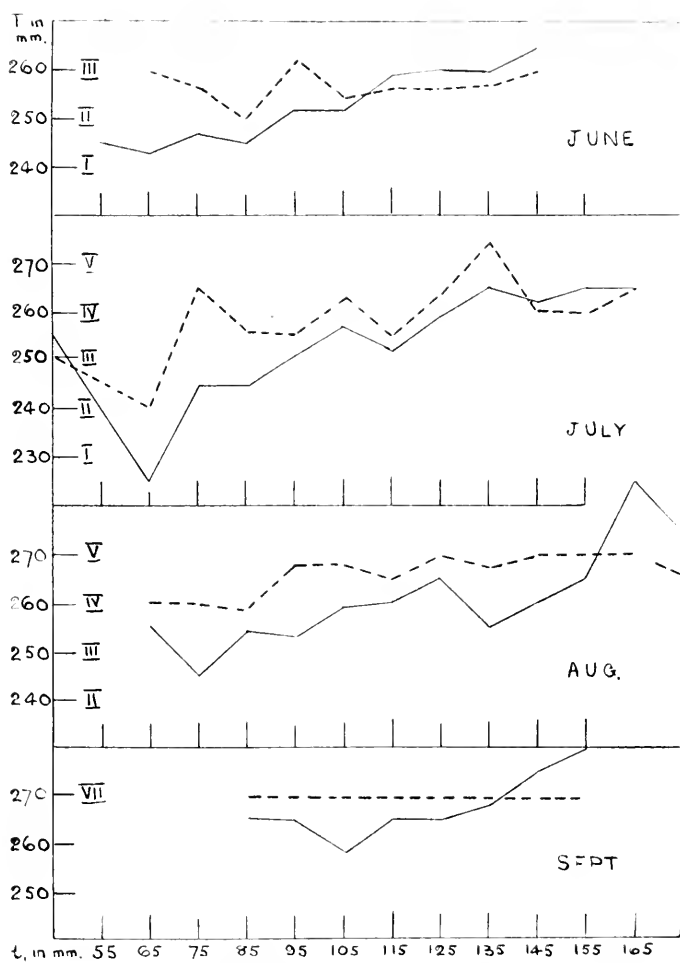


FIG. 4.—Manx Coastal 4-Ring Herring.

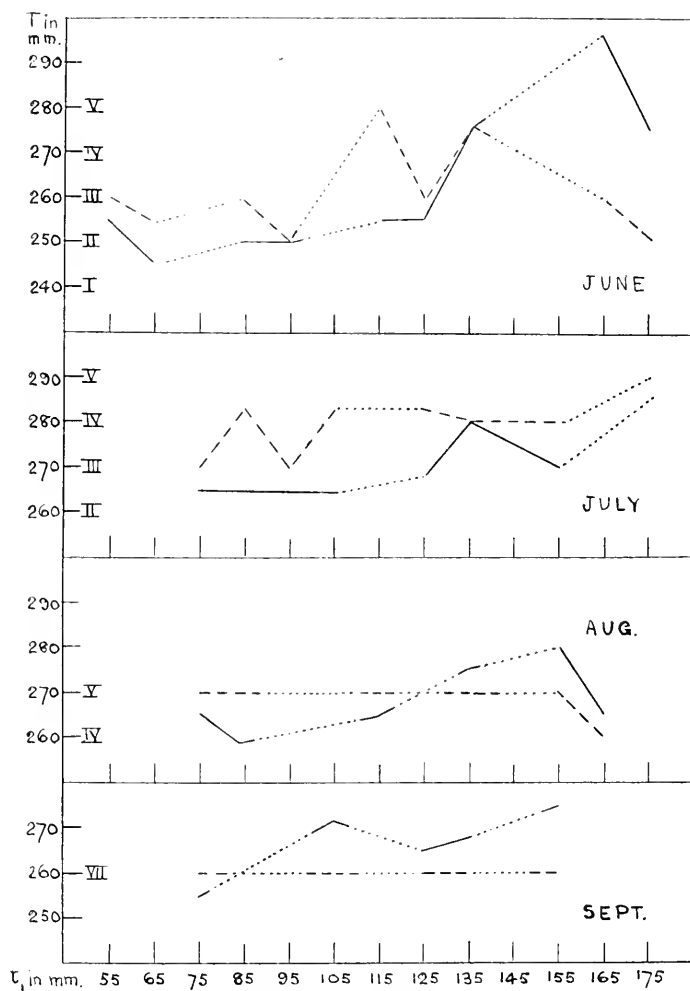


FIG. 5.—Manx Coastal 5-Ring Herrings.

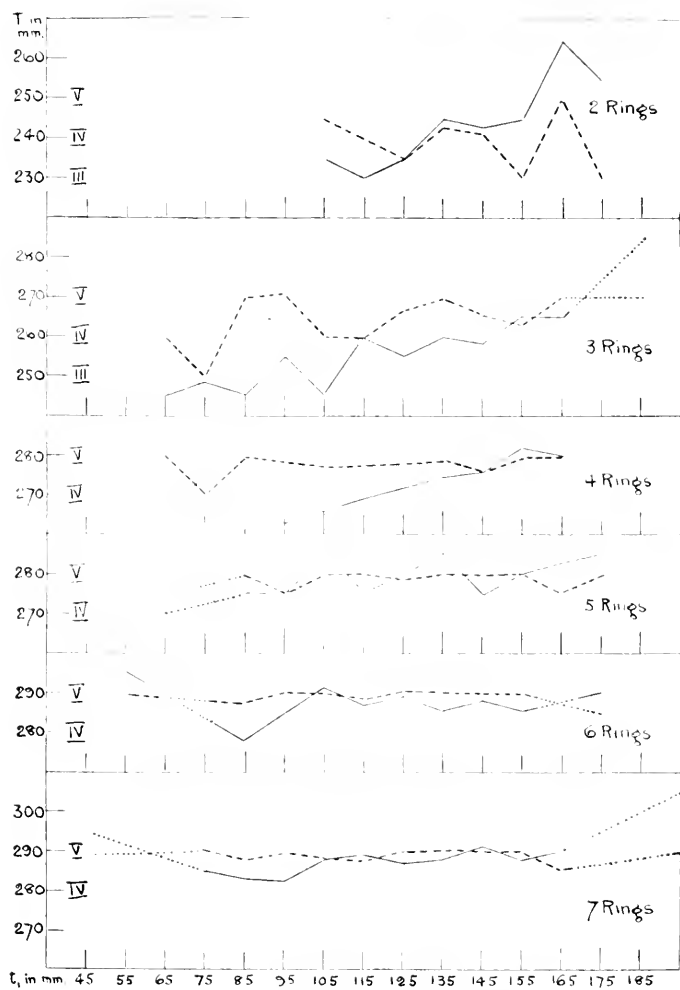


FIG. 6.—Lambay 2-7-Ring Herrings.

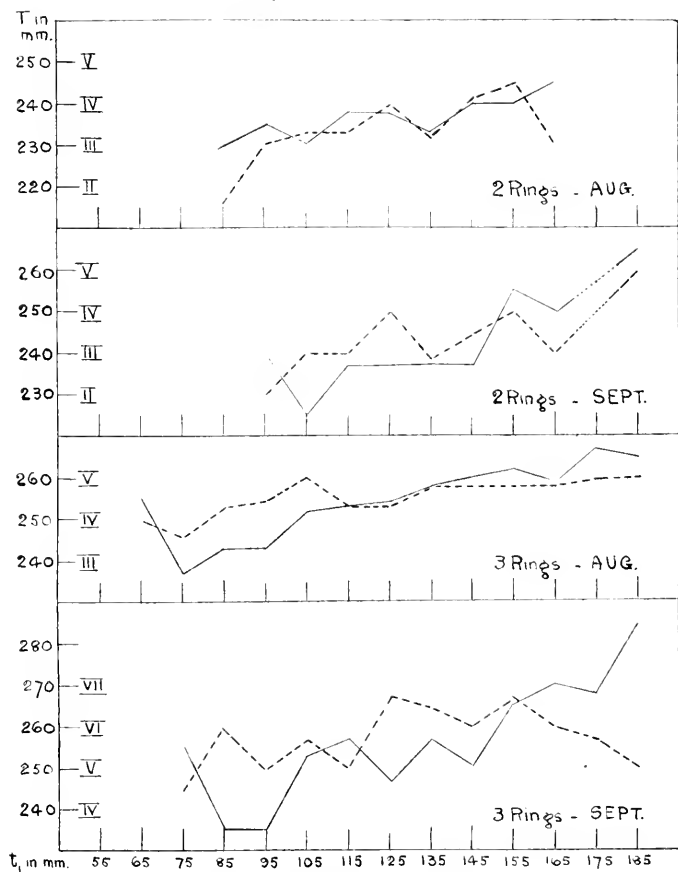


FIG. 7.—Calf 2—3-Ring Herrings.

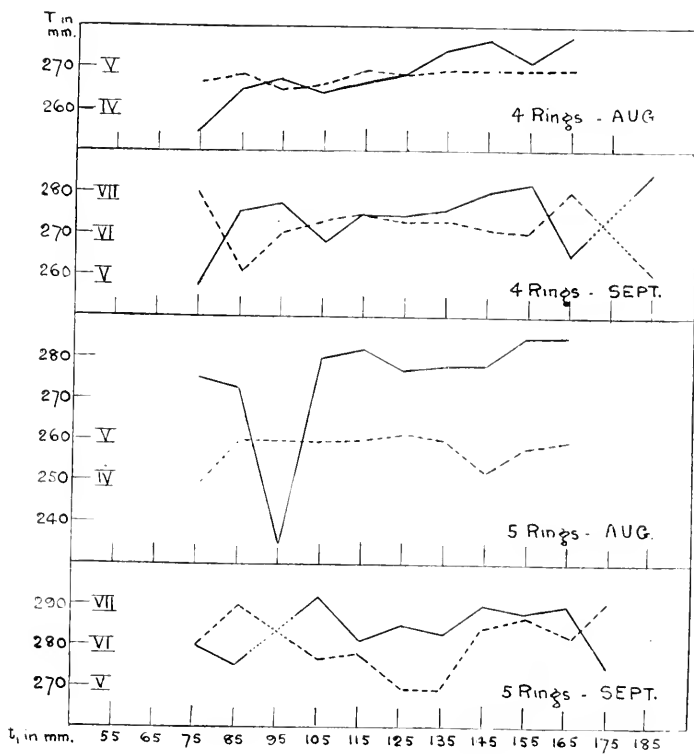


FIG. 8 --Calf 4—5-Ring Herrings.

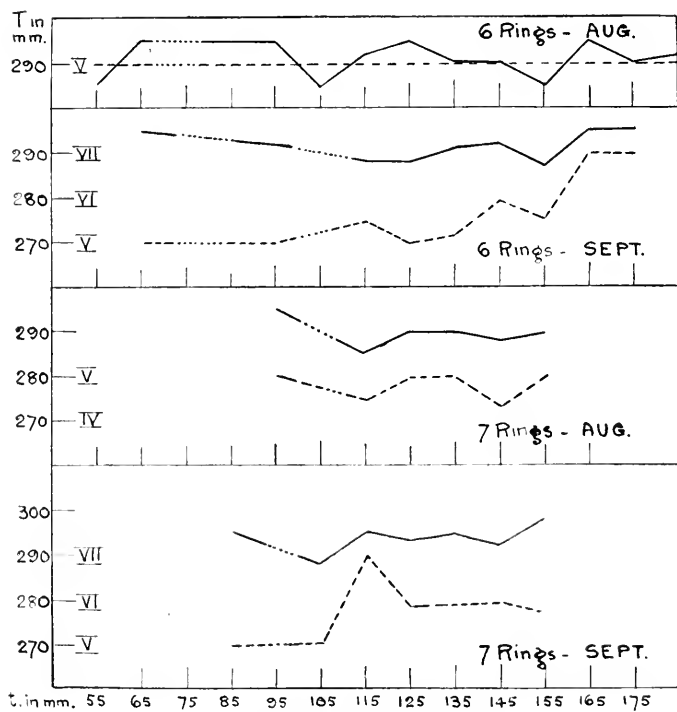


FIG. 9.—Calf 6—7-Ring Herrings.

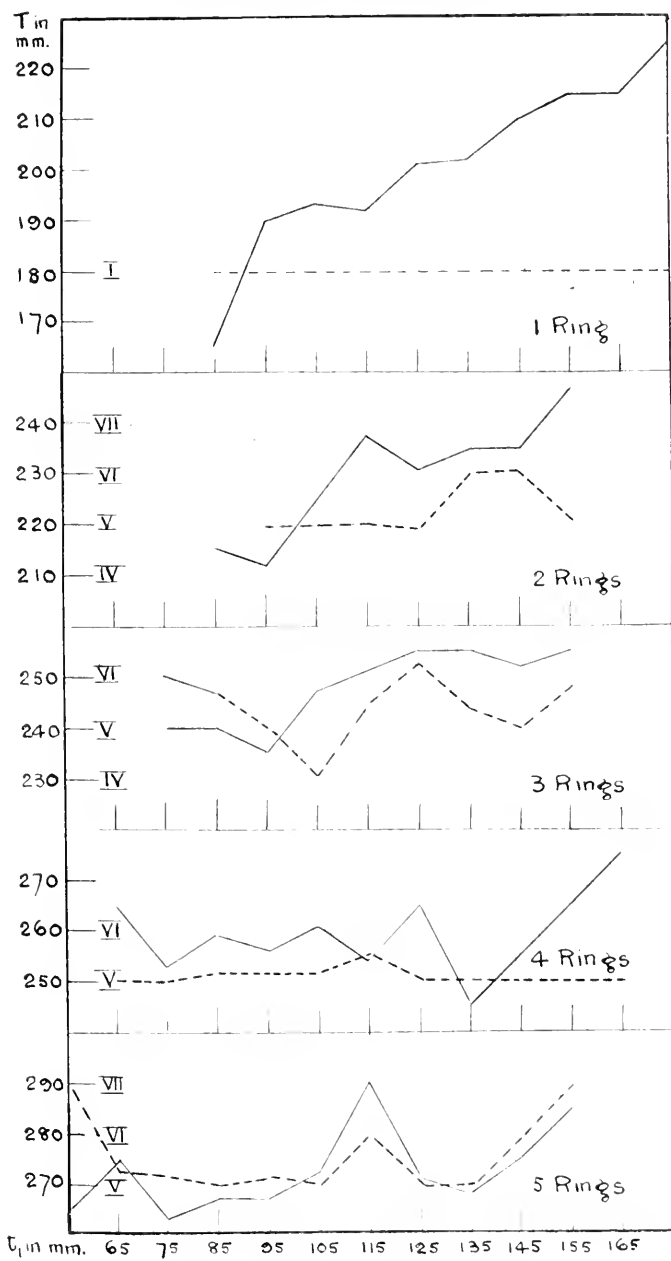


FIG. 10.—Penrhyn 1-5-Ring Herrings.

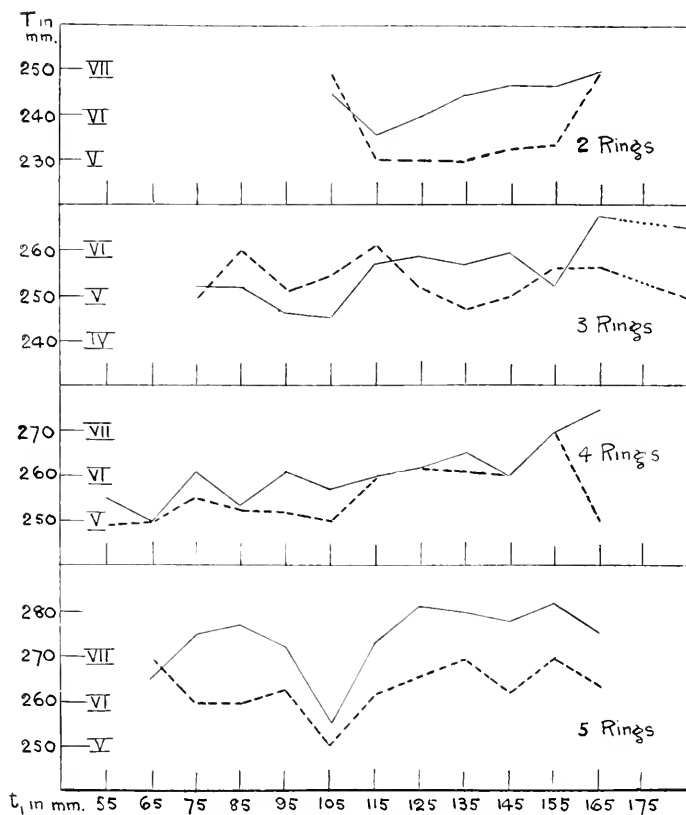


FIG. 11.—Moelfra 2—5-Ring Herring.

TABLE V. *Showing the mean observed length, T, and mean Stage of maturity, with frequencies, attained by Manx coastal, Lambay, Calf and Welsh herrings in 1923, grouped according to their calculated first year's growth, t_1 .*

Manx Coastal Herrings, June to September, 1923.

2 Rings

t_1 in mm.	June			July		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
75	2	215	I	3	218	I-66
85	9	219	I-75	11	219	I-27
95	7	215	II-12	9	226	I-88
105	22	221	II-18	17	229	I-75
115	11	224	II	28	226	I-75
125	28	225	II-10	35	232	II-17
135	19	230	II	29	234	II-53
145	11	233	I-88	23	234	II-57
155	7	235	II	8	236	II-75
165	1	255	...	...	...	...
175	1	235	II	...	...	...
185	1	235	...	...	...	...
...	119	226	...	163	230	...

t_1 in mm.	August			September		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
75	...	...	...	...	...	...
85	3	232	I-67	1	235	VII
95	9	221	III-25	1	225	VII
105	15	232	II-07	2	235	VII-II
115	17	233	III-18	5	235	VI
125	22	234	II-8	...	...	...
135	19	233	II-95	4	240	VI-5
145	12	237	III-08	1	235	V
155	9	241	III-67	2	250	VII
165	4	245	IV-5	...	...	...
175	...	...	...	...	...	...
185	...	...	...	...	...	...
...	110	234	...	16	237	...

TABLE V—*continued.*

3 Rings

t_1 in mm.	June			July		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
45	...	...	...	2	230	II
55	7	235	II	6	233	II-66
65	10	230	II	9	237	III
75	13	230	II	14	236	III
85	20	234	II-13	28	234	II-58
95	34	233	II-15	33	237	III-12
105	39	237	II-45	25	240	II-96
115	38	238	II-24	27	241	III-63
125	36	241	II-60	40	244	III-25
135	32	240	II-40	37	248	III-78
145	17	245	III	33	251	III-85
155	13	248	II-5	20	249	IV-15
165	5	249	II-25	8	256	IV-12
175	1	245	III	4	262	IV-25
...	265	238	...	286	243	...
t_1 in mm.	August			September		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
45	...	...	...	...	...	...
55	1	245	IV	...	...	...
65	4	232	III	...	...	...
75	7	229	II-86	4	247	VII
85	12	241	IV-08	2	250	VII
95	16	245	III-94	3	248	VII
105	26	245	III-96	4	240	VII
115	15	245	IV-07	4	255	VII
125	17	249	IV-12	1	245	VII
135	19	249	IV-21	5	251	VII
145	17	251	IV-47	2	265	VII
155	14	251	IV-36	1	245	VII
165	6	263	IV-50	2	265	VII
175	2	265	IV-50	1	265	VII
...	156	247	...	29	251	...

TABLE V—*continued*.

4 Rings

t ₁ in mm.	June			July		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
45	...	...	...	2	255	III-5
55	1	245	...	...	...	...
65	5	243	III	1	225	II
75	5	247	II-66	2	245	IV-5
85	12	245	II	10	245	III-6
95	8	252	III-25	14	251	III-57
105	14	252	II-50	10	257	IV-30
115	8	259	II-71	9	252	III-55
125	4	260	II-75	7	259	IV-43
135	4	260	II-75	11	265	V-50
145	1	265	III	4	262	IV
155	...	...	...	3	265	IV
165	...	...	...	3	265	IV-50
175	...	...	...	...	...	...
...	62	251	...	76	255	...

t ₁ in mm.	August			September		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
45	...	...	...	...	...	...
55	...	...	...	...	...	...
65	1	255	IV	...	...	...
75	1	245	IV	...	...	...
85	7	254	III-86	1	265	VII
95	5	253	IV-80	1	265	VII
105	9	259	IV-81	3	258	VII
115	4	260	IV-50	1	265	VII
125	2	265	V	4	265	VII
135	4	255	IV-75	3	268	VII
145	2	260	V	2	275	VII
155	2	265	V	...	...	...
165	1	285	V	2	280	VII
175	2	275	IV-50	...	...	...
...	40	259	...	17	267	...

TABLE V—*continued*.

5 Rings

t_1 in mm.	June			July		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
55	1	255	III	...	...	...
65	2	245	II-5	...	...	...
75	...	...	...	1	265	III
85	2	250	III	5	265	IV-33
95	2	250	II	1	265	III
105	...	...	...	3	265	IV-33
115	1	255	V	...	...	...
125	1	255	III	3	268	IV-33
135	1	275	IV	2	280	IV
145	...	...	...	1	275	IV
155	...	...	...	2	270	IV
165	1	295	III	...	...	...
175	1	275	II	1	285	V
...	12	258	...	19	269	...

t_1 in mm.	August			September		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
55	...	...	...	...	...	...
65	...	...	...	...	...	...
75	2	265	V	1	255	VII
85	3	258	V	...	...	...
95	...	...	...	...	...	...
105	...	...	...	4	272	VII
115	2	265	V	...	...	...
125	...	...	...	1	265	VII
135	1	275	V	3	268	VII
145	...	...	...	...	...	...
155	2	280	V	1	275	VII
165	1	265	IV	...	...	...
175	...	...	...	...	...	...
...	11	267	...	10	269	...

TABLE V—*continued.**Lambay Herrings, August, 1923.*

t_1 in mm.	2 Rings			3 Rings		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
45	...	...	...	...	...	...
55	...	...	...	...	...	...
65	...	...	...	1	245	IV
75	...	...	...	3	248	III
85	...	...	...	1	245	V
95	...	...	...	1	255	V
105	2	235	IV.50	1	245	IV
115	2	230	IV	2	260	IV
125	4	235	III.50	3	255	IV.66
135	6	245	IV.33	2	260	V
145	5	243	IV.09	7	258	IV.56
155	1	245	III	3	265	IV.33
165	1	265	V	3	265	V
175	1	255	III	...	...	...
185	...	...	...	1	285	V
195	...	...	...	...	...	...
...	22	242	...	28	258	...

t_1 in mm.	4 Rings			5 Rings		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
45	...	...	...	...	...	...
55	...	...	...	...	...	...
65	1	265	V	2	270	IV.50
75	1	275	IV	...	...	...
85	2	270	V	3	275	V
95	5	263	IV.80	5	275	IV.50
105	8	266	IV.75	1	285	V
115	10	269	IV.80	4	275	V
125	15	272	IV.80	8	280	IV.88
135	12	274	IV.92	7	285	V
145	8	276	IV.63	1	275	V
155	3	282	V	2	280	V
165	2	280	V	5	283	IV.60
175	...	...	...	1	285	V
185	...	...	...	...	...	...
195	...	...	...	...	...	...
...	67	272	...	39	279	...

PLATE V—*continued.**Lambay Herrings—continued.*

t ₁ in mm.	6 Rings			7 Rings		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
45	...	...	...	1	295	V
55	1	295	V	...	...	...
65	...	...	...	...	...	...
75	...	...	...	3	285	V
85	5	277	IV·75	5	283	IV·8
95	6	285	V	4	282	V
105	5	291	V	7	288	IV·86
115	5	287	IV·80	5	289	IV·8
125	9	289	V	5	287	V
135	4	285	V	6	288	V
145	7	288	V	5	291	V
155	2	285	V	4	287	V
165	...	...	...	2	290	IV·5
175	2	290	IV·50	...	...	...
185	...	...	...	...	...	...
195	...	...	...	1	305	V
...	46	287	...	48	288	...

Calf Herrings, August and September, 1923.

2 Rings

t ₁ in mm.	August			September		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
65	...	...	...	...	...	...
75	...	...	...	...	...	...
85	2	230	I·50	...	...	...
95	6	235	III	2	240	II
105	6	230	III·33	3	225	III
115	6	238	III·33	6	237	III
125	8	237	IV	9	237	IV
135	5	233	III·20	4	237	II·75
145	8	240	IV·12	4	237	IV·50
155	2	240	IV·5	1	255	IV
165	2	245	III	2	250	III
175	...	...	...	...	...	...
185	...	...	...	1	265	V
195	...	...	...	...	...	...
...	45	236	...	32	238	...

TABLE V—*continued.**Calf Herrings—continued.*

3 Rings

August				September		
t ₁ in mm.	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
65	1	255	IV	...	...	...
75	5	237	III-60	3	255	IV-50
85	6	243	IV-33	2	235	VI
95	5	243	IV-44	1	235	V
105	3	252	V	6	253	V-67
115	9	253	IV-33	5	257	V
125	15	254	IV-33	5	247	VI-66
135	9	258	IV-78	5	257	VI-40
145	6	260	IV-83	2	250	VI
155	12	262	IV-83	7	265	VI-73
165	5	259	IV-83	2	270	VI
175	4	267	V	3	268	V-66
185	1	265	V	1	285	V
195	...	...	...	1	275	V
...	81	254	...	43	257	...

4 Rings

August				September		
t ₁ in mm.	f.	Mean T in mm.	Mean Stage	f.	Mean T. in mm.	Mean Stage
75	3	255	IV-66	4	257	VII
85	12	265	IV-93	1	275	V
95	4	267	IV-50	4	277	VI
105	14	264	IV-65	6	268	VI-3
115	9	267	V	9	270	VI-55
125	11	269	IV-90	11	270	VI-27
135	6	275	V	12	276	VI-33
145	6	277	V	11	280	VI-09
155	4	272	V	4	282	VI
165	3	278	V	3	265	VII
175	...	...	...	...	...	...
185	...	...	...	1	285	V
...	72	268	...	66	273	...

TABLE V—*continued.**Calf Herrings—continued.*

5 Rings

t ₁ in mm.	August			September		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
75	1	275	IV	2	280	VI
85	4	272	V	1	275	VII
95	1	235	V	...	...	...
105	2	280	V	3	292	V-67
115	4	282	V	7	281	V-86
125	11	277	V-09	5	285	V
135	3	278	V	5	283	V
145	3	278	IV-66	8	290	VI-50
155	5	285	IV-83	3	288	VI-66
165	1	285	V	6	290	VI-33
175	...	...	...	1	275	VII
185	...	...	...	...	...	...
...	35	277	...	41	286	...

6 Rings

t ₁ in mm.	August			September		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
55	1	285	V	...	...	...
65	1	295	V	1	295	V
75	...	...	...	...	...	...
85	2	295	V	...	...	...
95	1	295	V	4	292	V
105	2	285	V	...	...	...
115	3	292	V	4	287	V-5
125	1	295	V	3	288	V
135	4	290	V	9	291	V-25
145	4	290	V	4	292	VI
155	2	285	V	4	287	V-5
165	1	295	V	1	295	VII
175	2	290	V	1	295	VII
185	3	292	V	...	...	...
...	27	291	...	31	290	...

TABLE V—*continued.**Calf Herrings—continued.*

7 Rings

t _l in mm.	August			September		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
55	...	...	...	...	...	...
65	...	...	...	...	...	...
75	...	...	...	...	...	...
85	...	...	...	1	295	V
95	1	295	V	...	...	...
105	...	...	...	3	288	V
115	2	285	IV-5	1	295	VII
125	2	290	V	5	293	V-8
135	2	290	V	1	295	V
145	3	288	IV-3	4	292	VI
155	2	290	V	3	298	V-67
165	...	...	...	...	...	...
175	...	...	...	...	...	...
185	...	...	...	...	...	...
...	12	289	...	18	293	...

Welsh Herrings, Penrhyn Fish Weir, November, 1923.

1 Ring

2 Rings

t _l in mm.	1 Ring			2 Rings		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
65	...	...	...	...	...	...
75	...	...	...	...	...	...
85	2	165	I	1	215	...
95	6	190	I	3	212	I-V
105	9	193	I	4	225	V
115	3	192	I	4	237	V
125	5	201	I	10	231	V
135	7	202	I	6	235	VI
145	4	210	I	3	235	VI
155	5	215	I	4	247	V
165	1	215	I	...	...	...
175	1	225	I	...	...	...
...	43	199	...	35	232	...

TABLE V—*continued.**Welsh Herrings, Penrhyn Fish Weir—continued.*

t ₁ in mm.	3 Rings			4 Rings		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
65	...	...	...	1	265	V
75	2	240	VI	12	253	V
85	4	240	V·7	9	259	V·22
95	1	235	V	11	256	V·18
105	4	247	IV	12	261	V·2
115	5	251	V·5	7	254	V·67
125	4	255	VI·33	2	265	V
135	5	255	V·4	1	245	V
145	3	252	V	1	255	V
155	5	255	V·8	1	265	V
165	...	...	...	1	275	V
175	...	...	...	...	...	...
...	33	250	...	58	257	...

t ₁ in mm.	5 Rings			6 Rings		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
55	1	265	VII	1	265	V
65	3	275	V·33	...	...	...
75	5	263	V·2	3	278	V
85	5	267	V	4	275	V
95	10	267	V·25	3	275	V
105	3	272	V	1	285	VII
115	2	290	VI	2	275	VI
125	5	271	V	1	295	V
135	3	268	V	...	...	...
145	1	275	...	1	295	V
155	2	285	VII	...	...	...
165	...	...	...	...	...	...
...	40	270	...	16	278	...

TABLE V—*continued.**Welsh Herrings, Penrhyn Fish Weir—continued.*

7 Rings

t_1 in mm.	f.	Mean T in mm.	Mean Stage	t_1 in mm.	f.	Mean T in mm.	Mean Stage
55	...	...	...	115	2	280	V
65	...	...	...	125	...	...	...
75	1	275	V	135	1	285	VII
85	...	...	...	145	1	295	VII
95	1	275	V	155	...	...	...
105	3	278	V-67	165	1	295	VII
...	...	...	...	...	10	282	...

Welsh Herrings, Moelfra anchored nets, November, 1923.

t_1 in mm.	2 Rings			3 Rings		
	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
55	...	...	...	...	...	...
65	...	...	...	...	...	...
75	...	...	...	3	252	V
85	...	...	...	4	252	VI
95	...	...	...	10	246	V-1
105	1	245	VII	4	245	V-5
115	7	236	V	5	257	VI-2
125	2	240	V	5	259	V-2
135	2	245	V	5	257	IV-8
145	6	247	V-33	4	260	V
155	5	247	V-4	3	252	V-67
165	1	255	VII	3	268	V-67
175	...	...	...	...	...	...
185	...	...	...	1	265	V
...	24	243	...	47	254	...

TABLE V—*continued.**Welsh Herrings, Moelfra anchored nets—continued.*

4 Rings.				5 Rings		
t_1 in mm.	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
55	1	255	V	...	...	...
65	2	250	V	1	265	VII
75	7	261	V-6	2	275	VI
85	7	254	V-3	5	277	VI
95	8	261	V-25	6	272	VI-33
105	4	257	V	1	255	V
115	2	260	VI	5	273	VI-2
125	6	262	VI-2	7	281	VI-71
135	5	265	VI-2	4	280	VII
145	4	260	VI	3	278	VI-33
155	2	270	VII	4	282	VII
165	1	275	V	3	275	VI-33
175	...	...	...	...	...	...
185	...	...	...	...	...	...
...	49	260	...	41	276	...

6 Rings				7 Rings		
t_1 in mm.	f.	Mean T in mm.	Mean Stage	f.	Mean T in mm.	Mean Stage
45	...	...	...	1	265	VII
55	1	275	V	...	...	...
65	...	...	...	1	275	VII
75	2	280	VI	3	282	V-67
85	...	...	...	2	285	VI
95	2	280	VI	3	278	V
105	1	285	VII	1	285	VII
115	1	275	VII	3	282	VII
125	1	285	VII	...	...	...
135	2	290	VI	3	282	VII
145	2	290	VI	...	...	...
155	1	285	VII	1	285	VII
165	...	...	...	...	...	...
...	13	283	...	18	281	...

TABLE VI.

Mean Calculated Yearly Growths of the 2-5-ring herrings from Manx Coastal Waters, from June to September, 1923.

				June				July			
Rings				2	3	4	5	2	3	4	5
				mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
t ₁	...	...	...	122	111	99	105	122	122	111	116
t ₂	...	...	...	76	69	79	77	77	66	74	72
t ₃	...	...	...	27	38	38	33	29	38	35	38
t ₄	...	...	...	...	17	20	17	...	21	20	30
t ₅	...	...	...	...	...	13	12	...	...	13	13
t ₆	...	...	...	...	...	...	8	...	...	...	9

				August				September			
Rings				2	3	4	5	2	3	4	5
				mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
t ₁	...	...	...	125	119	113	112	120	116	128	118
t ₂	...	...	...	76	67	74	69	77	69	75	75
t ₃	...	...	...	32	38	35	35	34	38	36	32
t ₄	...	...	...	...	21	20	27	...	25	20	20
t ₅	...	...	...	...	...	14	14	...	...	11	11
t ₆	...	...	...	...	...	...	11	...	...	...	9

Mean Calculated Yearly Growths of 2-7-ring herrings from Lambay, August, 1923.

Rings				2	3	4	5	6	7
				mm.	mm.	mm.	mm.	mm.	mm.
t ₁	...	...	...	135	130	123	124	120	119
t ₂	...	...	...	70	67	77	75	80	78
t ₃	...	...	...	35	37	38	37	38	37
t ₄	...	...	...	...	23	21	22	20	21
t ₅	...	...	...	...	...	12	12	10	11
t ₆	...	...	...	...	...	...	9	8	8
t ₇	...	...	...	...	...	...	...	7	7
t ₈	...	...	...	...	...	...	...	...	6

TABLE VI—*continued.*

Mean Calculated Yearly Growths of the 2—7-ring herrings from Calf grounds in August and September, 1923.

Rings	August						September					
	2	3	4	5	6	7	2	3	4	5	6	7
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
t ₁ ...	124	127	117	125	132	131	129	130	126	133	132	131
t ₂ ...	77	64	76	75	72	73	75	67	78	77	73	76
t ₃ ...	36	37	40	34	37	32	33	37	35	35	37	36
t ₄ ...	...	24	21	20	19	21	...	22	19	19	21	22
t ₅ ...	...	...	13	11	10	11	...	...	12	11	12	9
t ₆ ...	...	...	...	9	8	7	...	...	...	9	9	8
t ₇ ...	...	...	...	...	7	6	...	...	...	...	6	6
t ₈ ...	...	...	...	...	...	6	...	...	...	...	...	6

Mean Calculated Yearly Growth of 2—7-ring herrings from Penrhyn Fish Weirs and Moelfra, Wales, November, 1923.

		Penrhyn—November, 1923							Moelfra—November, 1923						
Rings		1	2	3	4	5	6	7	2	3	4	5	6	7	
		mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	
t ₁	...	123	125	120	98	100	94	116	134	117	106	118	110	98	
t ₂	...	80	73	69	79	79	82	77	72	68	77	79	78	76	
t ₃	34	35	39	42	45	39	35	39	38	38	41	45	
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t ₅	19	12	14	10	17	10	13	12	
t ₆	11	9	9	10	9	9	
t ₇	8	7	7	7	
t ₈	5	7	

DISEASED CONDITIONS IN FISHES.

BY JAS. JOHNSTONE.

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The following records of various forms of malignant and other diseases in marine fishes are of much interest. Some of them are quite novel: these are the occurrence of a typical angioma, a case of undoubted and typical goitre in a truly marine fish and a malignant tumour of the testis in a herring. Several other records: fibromata in the flesh and skin of Turbot and Haddock provide confirmation of conditions already noted and so they are given here. A knowledge of the *prevalent* forms of malignant tumours in marine fish is very desirable and, in the absence of any means of systematic search for such diseases in large numbers of fish, any isolated observations ought to be recorded.

1. Hard Fibroma in a Turbot.

By the kindness of Dr. Orton, of the Marine Biological Association, I was enabled to study a case of typical fibroma in a Turbot. The fish was about 18 inches in length, and it had a bluntly conical growth on the dorsal fin about half-way between the head and the tail, on the pigmented side of the body. The growth was hard and compact and measured about 1 inch in diameter at the base, and was about $1\frac{1}{2}$ inches in height. It was caught alive and was at once transferred to the tanks in the Aquarium. The possibility of keeping such an affected

fish alive and of observing the rate of growth of the tumour and the effect of this on the health of the fish was appreciated by Dr. Orton, and the turbot was closely watched. Hitherto no one has had the opportunity of making a "clinical" study of malignant disease in a marine fish, and this kind of knowledge is urgently wanted. Unfortunately, large turbot are exceedingly difficult to maintain in good health in aquarium tanks, and though every kind of care was exercised the fish died in less than a week. It was "healthy" in spite of the presence of the tumour, and its death was certainly due to the ordinary troubles of capture and captivity in the restricted volume of shallow water of an aquarium tank.

The part of the fish including the tumour was cut out by Dr. Orton and fixed in Bouin's fluid and the conditions of the tissues were very satisfactory. Sections were made and it was seen that the affection was similar in most respects to that described in last year's Report with regard also to a large turbot. The growth was a connective tissue one, beginning in the hard white connective tissue that lies directly beneath the epidermis. It was almost entirely fibrous in nature, thus differing from the turbot tumour described in last year's report—where there was a considerable admixture of small connective tissue cells. The coarse, connective tissue bundles composing the tumour in this case, ran in all directions and were often greatly convoluted. Towards the margins there were regions where the tissue was more loosely arranged than in the more compact regions towards the margins of the tumour. Everywhere the tumour tissue was normal in nature, that is, it had just the same structure as the connective tissue that underlies the epidermis or penetrates between the muscle bundles except that it was rather more dense. It had, of course, no business to be where it was, so to speak, and this constitutes the morbidity of the condition.

The tumour was a truly malignant one. There were no

definite boundaries between it and the surrounding healthy tissue and the latter was in the process of being infiltrated by the tumour tissue. The case is similar to several others that I have seen except that the tumour tissue is, perhaps, unusually dense and compact in its arrangement.

2. Multiple Fibromata in the Skin of a Haddock.

Several cases of cutaneous "warts" in the skin of Halibut and other fishes have already been recorded. The present example I owe to the kindness of Mr. G. Driver, Inspector at Bradford. The fish was a large haddock, and was sufficiently notable in appearance to be seized in the market.

All parts of the skin and fins were covered by little wart-like structures which were, on the average, about 5 millimetres in diameter and were usually raised up several millimetres above the general level of the skin. Usually they were whiter than the normal skin—an effect due to the absence of the epidermis. Round them the scales were loose and were lifted up at their free margins, but on the regions of the warts themselves there were no scales. Here the dense sub-epidermal layer which is characteristic of such fish as this one came to the surface. The warts themselves were merely local thickenings of this fibrous layer.

An attempt was made to isolate, fix and cut one of the little warts on the side of the fish. The presence of the surrounding scales made these sections very unsatisfactory, and so one of the tumours growing on the lower surface of a pectoral fin was studied. The part of the fin including the wart was cut out, fixed in formalin and decalcified by treatment with Mayer's nitric acid-alcohol reagent. The sections were very satisfactory, and one of them is represented in Fig. 1.

The various tissue elements to be seen in the section are represented conventionally: the wart itself, however, has very much the structure that is shown in the figure. The black

parts are cross-sections of the fin-rays. Over the normal part of the section the integument consists of a thick layer of coarse connective tissue fibres, most of which run parallel to the surface. There is no evident epidermis, and it is likely that this has been removed by abrasion consequent on the handling of the fish. Very often no apparent epidermis can be seen in the skin of a fish that has not been handled with unusual care.

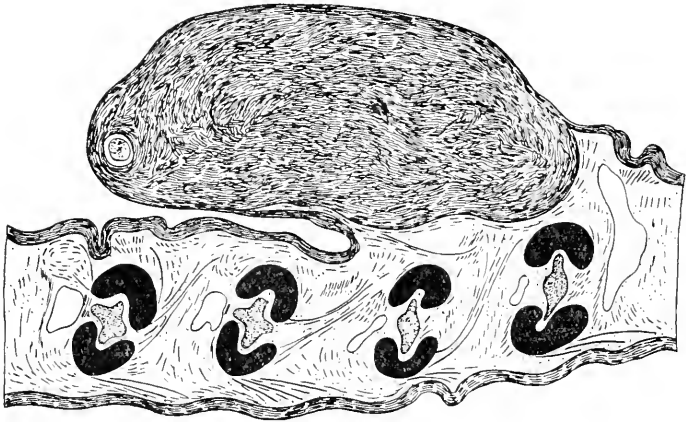


FIG. 1. Section of part of the pectoral fin taken perpendicular to the fin rays. The fin at this part carries a typical wart, which is about 5 mm. in the long diameter represented in the section.

Clearly the "wart" or nodular swelling, is a localised overgrowth of the sub-epidermal connective tissue layer. In many of the little tumours seen in the skin of this fish, as well as in others that have been studied there is simply a localised thickening of the layer in question. In the case of the "wart" shown in Fig. 1, however, the overgrowth projects out boldly from the general surface, and its attachment to the parent tissues is rather slender. The growth consists of fibres, many of which run in all directions, though there is a general tendency for most of them to run roughly parallel to the surface of the tumour. Here and there are some very small connective

tissue cells, which have exceedingly little cell substance. Towards the surface of the tumour the fibres have a colloidal appearance—as if they had partially fused together so that their outlines had become rather blurred and indistinct. This appearance can, however, be seen in some parts of the normal integument and it may be the result of imperfect fixation. In the section shown there is an obvious inclusion with a distinct structure of some kind.

These wart-like growths resemble cutaneous papillomata. Nowhere are there any certain traces of epidermal tissue and so I simply describe them as multiple cutaneous fibromata.

3. Epithelioma in the Mouth of a Whiting.

A cutaneous growth consisting initially and typically of a downgrowth of epidermal tissue would be an epithelioma. It is essential to the idea of the latter that the bounding membrane—either the epidermis, or the epithelial lining of such a cavity as that of the mouth, should infiltrate the lower tissues and destroy some of the latter. Also parts of this proliferating epithelium usually become detached from the parent tissue, thus appearing in the sub-epithelial region as small globular nodules. These become capsulated and are generally known as “epithelial pearls.” Thus, in an epithelioma, there is the initial proliferating epidermis, or epithelium, and a secondary growth of fibrous tissue coming from the structures that have been invaded by the intrusive epiblastic cell masses.

So far I have not seen any malignant growth in fishes that could certainly be identified as an epithelioma and the case now described has some interest. Fig. 2 shows the appearance of the tumour: it was a papillated growth of about 1 cm. in diameter and was very noticeable. The growth was mainly on the outer surface of the mandible but it also extended into the cavity of the mouth. The mandible of the side exhibiting

the tumour was cut out, fixed in 10 per cent. formalin, decalcified and the morbid part was cut into sections.

Considering first the normal structures we see the various bones of the lower jaw (represented in black) with Meckel's cartilage (the lightly stippled round part in the centre of the section). There is a prominent and thick epidermis on the upper and lower surfaces (this is stippled in the figure). For the rest there are bundles of muscle fibres, mostly cut transversely, prominent nerves and blood vessels, etc.: these details are not shown in the figures. A glance at A, which

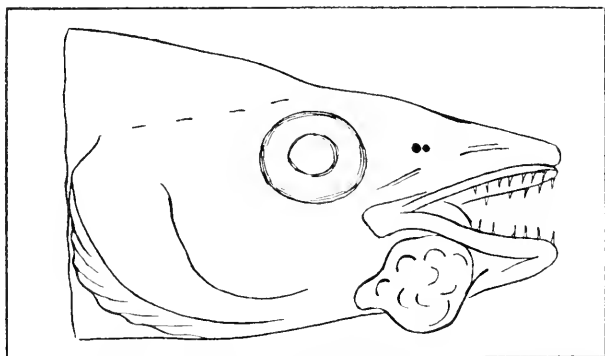


FIG. 2. Head of a whiting (represented in natural size) showing an epithelial tumour on the lower lip.

represents the full development of the tumour shows that Meckel's cartilage has quite disappeared and there is a considerable reduction in the size of the bones while there are only a few traces of the normal musculature of the jaw. The epidermis has also thinned out or has disappeared completely. The tissue of the tumour consists of a dense mass of small globular bodies, looking rather like cysts containing parasitic remains. These are, however, bodies of the nature of the "epithelial pearls" that are often found associated with epitheliomatous tumours.

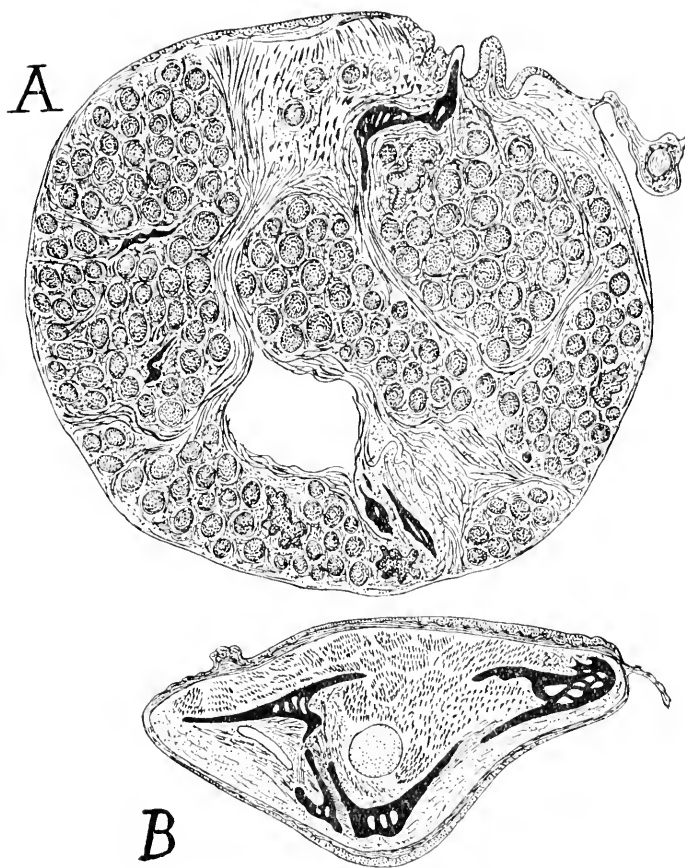


FIG. 3. A—Transverse section of the mandible near the middle part of the tumour. B—Transverse section of a normal mandible in the same region. Both sections are drawn to the same scale.

Part of the tumour tissue is drawn to a much larger scale as Fig. 4. The black area is part of one of the bones of the jaw and to the left of it is seen a tooth germ. On the upper (that is the oral surface) of the mandible the epithelium is unusually thick, and below this are the structures regarded as "epithelial pearls." Not all of the latter are globular but many can be seen to be short anastomosing cords. They are contained in a rather dense areolar tissue which is highly vascular in places, particularly just beneath the skin.

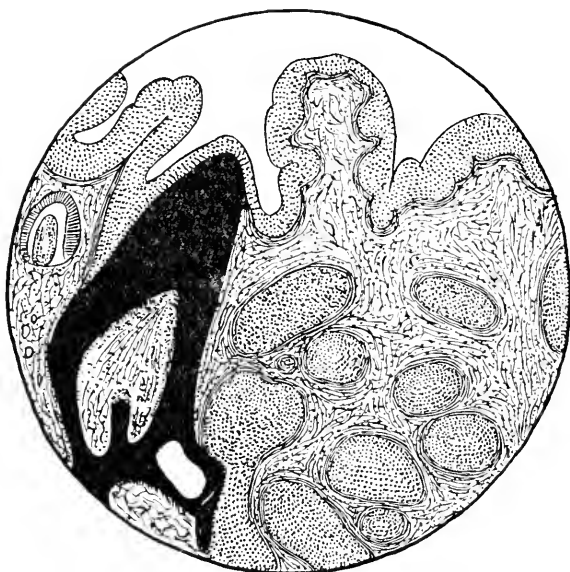


FIG. 4. Part of the same section as that represented in Fig. 3, A, but drawn on a larger scale.

The minute structure of the so-called "pearls" is represented in Fig. 6, but, first of all, we may look at that of the normal epithelium: this is shown in Fig. 5.

The skin consists of two layers: (1) the external epidermis and (2) the underlying coarse white fibrous layer. These are not of uniform thickness and in some places (both in the morbid

and normal regions) the epidermis may almost disappear so that the fibrous layer seems to come to the surface. Further, the fibrous layer rises up, in papillae and ridges, into the

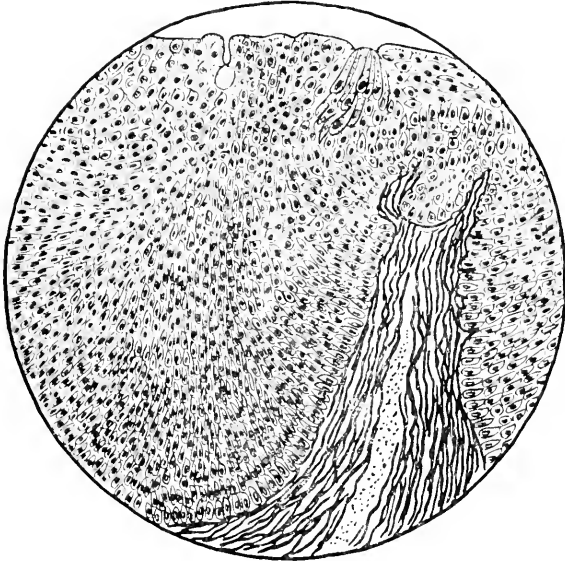


FIG. 5. Part of the normal epithelium on the oral surface of the mandibles as seen under an oil immersion lens.

epidermis as is indicated in Fig. 4, and one of these papillae, or ridges, is shown in the field represented by Fig. 5. Here (and elsewhere) in the lower layer of the skin the coarse white fibres run in gently undulating courses: in the papilla they are thrust up towards the epidermis, where they end in a truncated way. Among these fibres there are a few small connective tissue cells and other more obscure tissue elements.

The epidermal cells are typically polyhedral in shape, but they vary a little in different levels. There is a very sharp boundary between the epidermal and fibrous layers—this being formed by a very regular layer of epidermal cells which are uniformly columnar in shape and are arranged with their long

axes normal to the curved surface of the fibrous layer. Adjacent to these the cells are in the forms of short spindles with their long axes taking the directions indicated by the basal cells. Towards the surface the cells become obscurely polygonal in most of their sections and they are very rarely squamous. At the very surface there is an irregular and very thin "limiting membrane." Here and there are goblet cells and there are also bundles of long columnar cells opening into shallow pits. One of these is shown in Fig. 5: they are probably sense organs of some kind. The whole epidermal structure is rather peculiar.

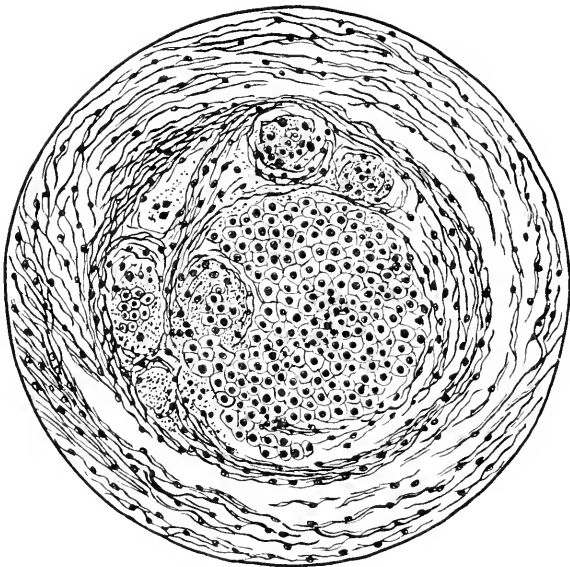


FIG. 6. One of the "epithelial pearls" as seen under an oil immersion lens.

The morbid tissue is shown in detail in Fig. 6, which represents one of the "pearls" cut tangentially. In the centre there is a tissue which is very similar to that of the epidermis and which stains in a very similar way with most

reagents. In the normal epidermis, however, the cells are not in actual contact but are separated in much the same way as are those of the deeper layers of the mammalian epidermis (this is indicated in Fig. 5). There are, however, no evident traces of the prickles of the typical epidermal cells (although I have seen these in other fish skins and their absence in the present case is doubtless the result of faulty preservation). Now, in the central tissue of the pearls the cells are closely opposed so that, at the best, only faint polygonal outlines are apparent, with nuclei at the centres of the spaces so delimited. In many places this central tissue breaks down still further so that irregular colloidal spaces are seen. In other places there are indications of multinuclear structures resulting, doubtless, from the fusion of numbers of cell-bodies.

Round each pearl is a very evident, though rather loose capsule formed from fine connective tissue fibres containing small nuclei and independent connective tissue cells. As a rule this is fairly distinct from the connective tissue in which it is embedded though there is no very sharp boundary. Between the pearls there is this fine fibrous tissue, sometimes approaching to the areolar type of structure, but mostly fibrous and arranged obviously with respect to the pearls. It is vascular and in some places very markedly so.

Evidently what we have here is an epithelioma with the formation of epithelial pearls. This has resulted from the downgrowth of the epidermis, with the pinching-off of cords, or masses of cells. Then the latter, after losing direct continuity with the parent layer have undergone proliferation with the result that little anastomosing cords of cells, and irregularly globular bodies, the so-called "epithelial pearls" have come into existence. The proliferation has been very active so that a very obvious tumour has been formed. But accompanying this proliferation of epidermis into the deeper layers there has also been an overgrowth of the subcutaneous areolar

connective tissue so that each of the pearls has become invested with a thick fibrous capsule.

It must be admitted that no actual structural continuity of the tumour tissue with that of the epidermis has been seen in any of the sections made : nevertheless, I have little doubt that the condition is that of an epitheliomatous growth.

4. Sarcoma on the Testis of a Herring.

In nearly every case of malignant tumours of fish that I have seen, the tissue that undergoes proliferation and extension is that which forms the integument and the connective tissue that holds together the muscle bundles and fibres. As a general rule, therefore, it is tissue of mesoblastic origin that takes on malignant growth in fishes. The tumour just described is undoubtedly exceptional in nature in that it comes from the epidermis, that is, a structure of epiblastic origin. The case which I am about to deal with is also exceptional in that it is associated with the reproductive organs.

It is that of a full-grown herring landed at Peel, in Isle of Man, in July, 1923. At that time a large number of herrings were being examined in detail for age, sexual maturity, rate of growth, etc., and this specimen was put aside by Mr. Birtwistle as a pregnant female. On opening it, however, it was seen that the distension of the abdomen was due to a large tumour occupying the site of the gonads. The gut and liver were quite normal and part of one testis could be seen, but the other testis could not be recognised. The tumour lay loosely in the body cavity except for some slight mesenterial attachments. It was roughly cylindrical in form, about $3\frac{1}{2}$ inches in length and about 1 to $1\frac{1}{2}$ inches in diameter. It was papillated on the exterior and was creamy white in colour. About half-way down its length there was a rough cleft and from this projected an organ which proved to be an unripe testis, quite normal in structure. The tumour was cut by a sharp razor into about

half a dozen parts by transverse sections and the testis could be traced back from its free extremity. It gradually became included in the general substance of the tumour so that it was indistinguishable from the tissues of the latter.

The hand sections showed that the tumour resembled the angiosarcoma described on p. 204 of this Report. It was evidently a complex system of cavities which were filled with some nearly homogeneous material. There was much black pigment about the central parts. Microscopic sections were then made and were stained in various ways. With Mallory's reagents there were seen large areas of the section staining in brilliant orange, reds and blues, and representing some nearly homogeneous, rather hyaline material. Between these areas were others filled with small round cells.

Sections stained with haematoxylin and eosin showed that the apparently homogeneous areas were densely crowded with small nuclei, and here and there cell outlines could just be distinguished. Then it became evident that the large spaces filled with homogeneous material were really sections of blood vessels, largely distended and with greatly altered contents. That is, we have something in the nature of an angioma: a great proliferation of the blood vessels, much retardation of the flow through the latter, thrombosis, or some similar process leading to coagulation and chemical alteration of the blood so that the staining reactions became greatly modified.

About one half of the whole area of a transverse section was made up of these distended and altered blood vessels and the remainder consisted of sarcomatous tissue. Fig. 7 represents part of a section, a field being chosen where these cells were more loosely arranged than elsewhere: in other fields these cells might have been so closely opposed as to become polyhedral by mutual pressure. Most of the section examined contained rather tightly packed cell masses. Unlike most other

fish sarcomata that I have seen this one contained very little fibrous tissue, and the cells represented in Fig. 7 were often continued right up to the outer margin of the tumour, where there was only a very thin limiting membrane.

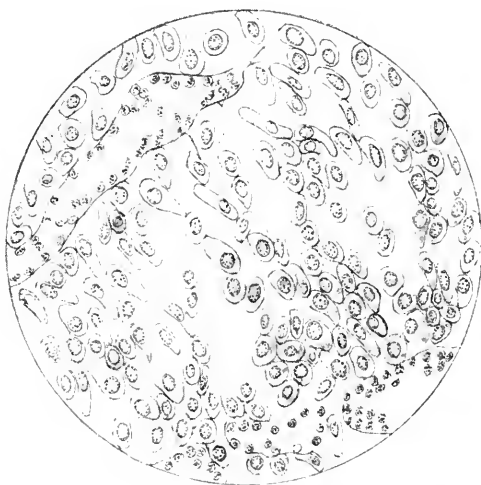


FIG. 7. Part of the tumour showing the cell matrix between the vascular spaces. Oil immersion lens. The cells represented are from about 15 to 20 μ in diameter.

These cells are different from most other fish sarcomatous ones that I have seen. They are spherical, ellipsoidal, or even spindle shaped. Their polyhedral shapes in some parts of the sections are due to mutual pressure; normally they are spherical. Here and there one sees distinct spindles, and this is especially the case where the cells cluster round a capillary blood vessel, or even one of the larger blood spaces having coagulated blood substance. Sometimes the spindle formation may even suggest a columnar epithelium round one of the larger blood spaces. There is, however, a tendency for the cells to assume the spindle shape even apart from their positions with regard to the blood spaces.

Evidently, then, the tumour is a true neoplasm. There

have been two proliferative processes at work : (1) a great development of the vascular tissue so that something like an angiomatous tumour has been formed and this has been followed by a process of thrombosis so that the contents of the blood vessels have become profoundly altered. (2) There has been a simultaneous proliferation of some of the cells of the tissues of the testis so that we have the sarcomatous part of the tumour as seen in the kind of matrix of undifferentiated epithelial cells that lies in between the vascular part of the tumour. There is hardly any fibrous tissue. The specimen is interesting as being the first case observed of a malignant tumour on the reproductive organs of a marine fish.

5. Colloidal Goitre in *Box Vulgaris*.

It has been noted, in previous Reports in this series, that true carcinomatous tumours are certainly of very rare occurrence in fishes. I have seen none in the numerous specimens of diseased fishes sent to this laboratory, and the literature (so far as I know it) contains only one record (in the early reports of the British Institute for Cancer Research). I except the well-known cases of so-called carcinoma of the thyroid described by Gaylord and Marsh.*

These workers made an extensive investigation into the nature of the "throat disease" found in salmon and other fresh-water fish reared or kept in captivity in fish cultural establishments in the United States of America. Such disease was experienced in the form of extensive epidemics and it was (and is) even endemic in many hatcheries and other stations. The main points brought out in this investigation were as follows :—

The disease was (1) simple hyperplasia of the thyroid, or (2) a condition not easily distinguishable from true carcinoma.

* "Carcinoma of the Thyroid in the Salmonoid Fishes." *Bull. Bureau of Fisheries, U.S.A.*, Vol. 32, 1912 (1914). Washington. pp. 363-524. Plates LVI-CX.

It was malignant in that tumours of the thyroid were able to infiltrate the adjacent tissues in a typical manner. True metastases were observed in two occasions.

It was endemic in some establishments. It was highly infectious and the infective agent was conveyed by the water in which the fish were living and was retained by the materials of which the tanks and ponds were constructed.

Some species of fish were immune. Those that were immune to injury by certain parasitic copepods (for instance *Lerneonema*) were also immune to the throat disease. There was some evidence (but this was not very convincing) that nematode worms might also convey the infective agent.

There was a very interesting relation between the incidence of the disease and the nature of the food. The disease was favoured by feeding the fish with uncooked meats (chopped bullocks' hearts, for instance) and it was retarded by feeding with natural food substances such as fresh-water molluscs.

Iodine or its salts, and the salts of mercury and arsenic, dissolved in the water supplied to the fish led to regression of the tumours.

It is to be noted that practically all the fish displaying this thyroid disease were those that had either been reared in captivity or were kept in captivity in small ponds and tanks. A few specimens were obtained of fish living in wild conditions and yet affected in a typical manner. Yet these were fresh-water fish, and the possibility that most of them had come from larvae reared in the fish cultural establishments could not be wholly excluded.

The present case is, therefore, of much interest in that it shows, in typical form, the "throat disease" which has hitherto only been observed in fresh-water fishes. The animal was a *Box vulgaris* landed by a steam trawler from near Trevose and obtained by the collectors of the Marine Biological Association.

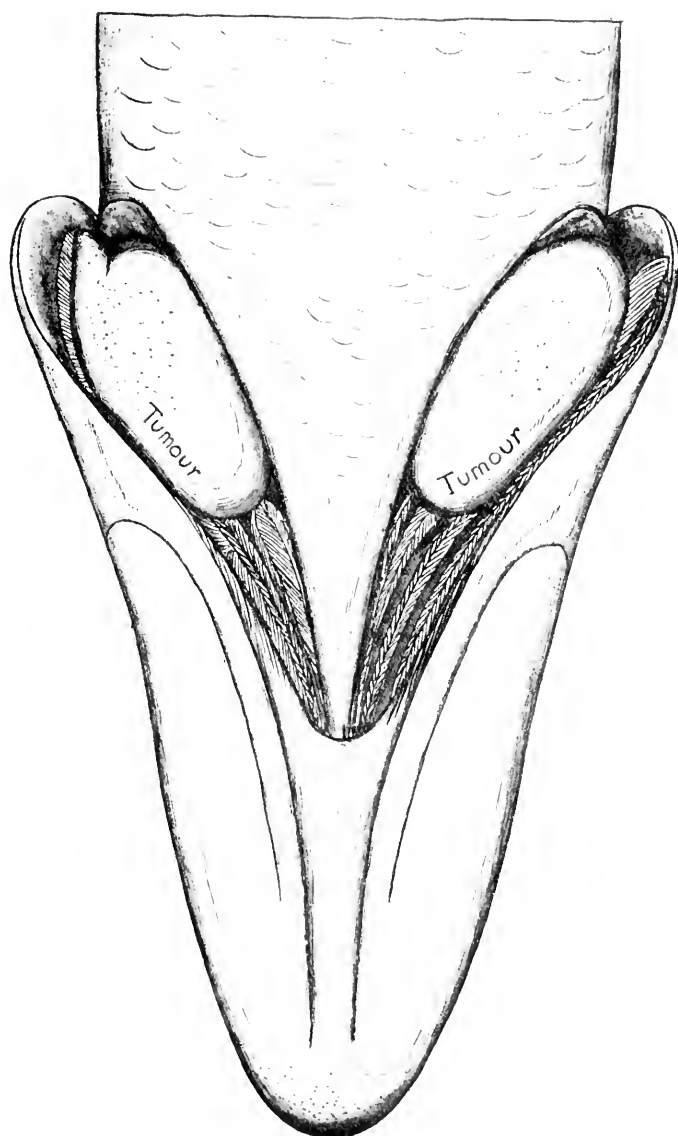


FIG. 8. The head of a *Box vulgaris* seen from the lower side. Nat. size.

It was sent to me by Dr. Allen, to whom I am indebted for the opportunity of studying a highly interesting specimen. *Box vulgaris* is a typical marine fish so there can be no doubt that the affection is not exclusive to fishes retained in captivity.

The fish was about 36 cms. in total length. The lower surface of the head is represented (natural size).

It will be seen that there are two very large tumours, one in each of the opercular cavities. The fish has been drawn just as it was received and the gill-covers have not been pressed apart. Now the thyroid in such a fish as this is a small diffuse gland consisting of scattered acini in the neighbourhood of the ventral aorta. It is not always easy to recognise. Here, however, we see two relatively enormous tumours, each of them being about $2\frac{1}{2}$ and $1\frac{1}{4}$ cms. in diameters. The morbid overgrowth of the gland has, therefore, been very great since it has pushed itself out on either side into the opercular cavities pressing the gills outwards and forwards.

Sections were made from one of the tumours, a thick slice being cut from about its middle part. The fixation of the specimen was made in 10 per cent. formalin and the preservation was excellent. The sections were stained with Mayer's glychaemalum, followed by eosin. Now it is clear from an inspection of Fig. 9 that we have to do with an overgrowth of the thyroid gland. There are large numbers of gland acini of very various diameters. The largest of these are about 1 mm. in diameter. They have relatively thin walls and, as a rule, they have the typical contents. They are surrounded by a stroma consisting of fine fibrous tissue containing numerous capillary blood vessels.

Further details as to the structure of the acini are shown in Fig. 10, which represents the structure of the wall of one of the acini and part of the stroma.

In Fig. 10, A. we have a part of one of the gland acini as it can be seen under an oil immersion lens. The structures

below the epithelium are the general stroma of the tumour, and above it is represented the contents of the acinus. The epithelium is markedly columnar. The cells are about 0.025 mm. in height, and the elongated nuclei are contained in the

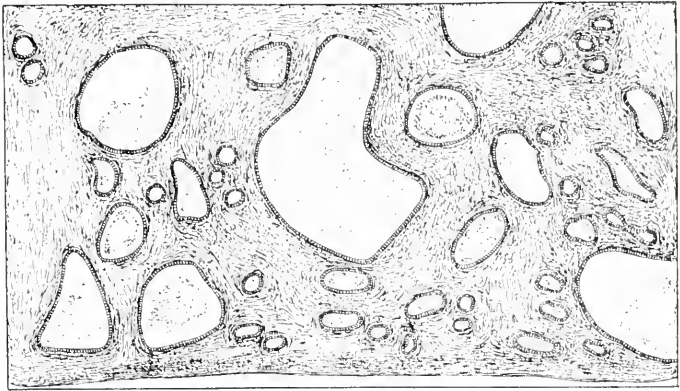


FIG. 9. Section of part of a Tumour. Mag. about 20 dia.

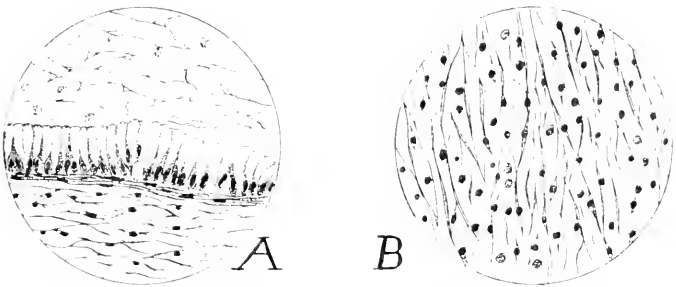


FIG. 10. A—Part of the wall of a gland acinus. B—The stroma outside the acinus. Oil immersion. The height of the epithelium in A is about 0.025 mm.

basal parts. Each nucleus is surrounded by a zone of deeply staining protoplasm. The upper parts of the cells stain less deeply and they contain large numbers of faintly staining

large and small granules. Within the acini is the colloidal substance which does not stain well with any of the reagents tried (glychaemalum, methyl-blue-eosin, and Mallory's combination). Within many of the acini there is a faintly staining reticulum (which is, however, more distinctly shown in the drawing than it was in the sections). Rounded bodies, as represented in Fig. 10, A, can be seen in most of the acini: these stain faintly, are finely granular in appearance and appear to be inclusions that have been discharged bodily from the epithelial cells into the cavities of the acini. It is only these granular bodies, and the delicate reticulum that stain even faintly for the true colloidal substance of the acini does not appear to have taken up the stains that were tried.

A further stage in the secretory activity of the gland epithelium is represented in Fig. 11, A. The nuclei of the cells are now rather smaller, they stain less densely, and each has become surrounded by a small quantity of densely staining cell substance. On the whole the cell protoplasm appears to be reduced in quantity relatively to the stage represented by Fig. 10, A. The larger parts of the cells consist of faint granular substance which stains very lightly. Here and there are vacuolated, or even broken-down cells and this means that large blocks of the cell substance become thrown out into the cavities of the acini so as to form the granular bodies shown in Fig. 10, A. It is not the granules of the epithelial cells that are discharged into the vesicles, but masses of the cells themselves loaded with these granules. For a time these cell inclusions persist in the cavities of the acini but gradually they become broken down and the major part of their substance no doubt passes into the colloidal contents.

The resting stage of the gland epithelium appears to be that represented in Fig. 11, B. The cells are now roughly cubical ones, staining rather darkly and containing nuclei that can only be seen with a little difficulty. In no case was a squamous epithelium seen.

The inter-vesicular gland stroma is represented by Fig. 10, B. It is a very characteristic connective tissue consisting of a fine fibrous substance, distinctly reticular in structure. It contains (especially at the nodal points) numerous small round cells with relatively large nuclei. Here and there are other cells, large and small, lying freely in the interspaces of the reticulum.

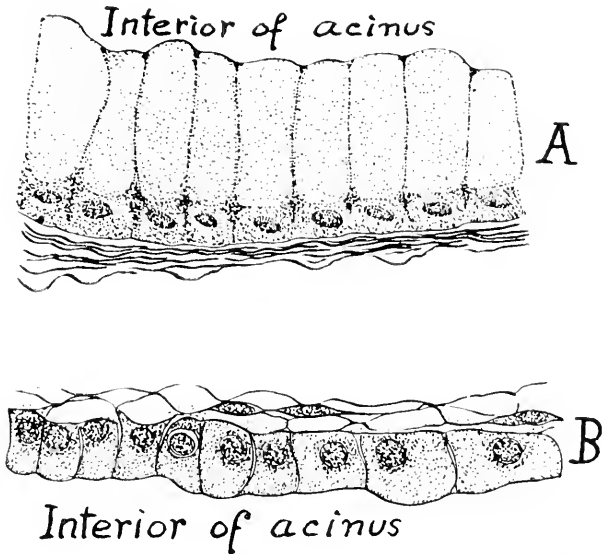


FIG. 11. A—Part of the wall of a gland acinus in a state of active secretion. B—Part of the wall of an acinus in which secretion has become minimal. Oil immersion lens.

The stroma is rather vascular. It packs together the gland vesicles in a compact fashion and its mass, relatively to that of the vesicles, can be seen in Fig. 9. On the margins of the tumours it is differentiated into marked fibrous investing layer.

NATURE OF THE TUMOURS.

It is clear that these thyroid tumours are not typical carcinomata. Their external appearance does, indeed, resemble in all particulars that of the tumours which Gaylord and Marsh term "thyroid carcinomata." But the histology does not

closely resemble that of thyroid tumours of mammalian animals: nothing suggests those appearances called proliferating struma, carcinomatous struma or malignant papilloma. Further, we should expect to see, in a malignant tumour of the thyroid, gland tissue arranged in irregular cords or papillating nodules and containing either no colloidal substances or very little of this. Again, the tumour ought to infiltrate and destroy the surrounding tissues and (although the specimen has not yet been carefully dissected) there is no indication in the adjacent parts of this destructive infiltration. There are no recognisable metastases anywhere in the body of the fish.

Nor does it seem that we have to do with a case of simple hyperplasia of the thyroid because there is far too much of the inter-vesicular connective tissue stroma: the appearance of this rather suggests an inflammatory process. Plainly what we have, in this specimen is an enormously overgrown thyroid—an organ which is, perhaps, several thousands of times larger than it is in a normal fish. Even when hypertrophied to this extent the gland is still an actively secreting organ, and its acini are, perhaps, in the condition of becoming enlarged and loaded with colloid. One can easily imagine a further stage in which this enlargement of the acini would end in the cessation of secretion; the reduction of the columnar and cubical epithelia to the squamous condition and the appearance of a typical “colloidal goitre.” This is what we doubtless have, and the study of further examples of the affection among marine fishes would be highly interesting.

6. Angiosarcoma in a Mackerel.

I describe here a highly interesting tumour found in a mackerel caught by a motor drifter near the Eddystone Lighthouse, in November, 1923, and I am indebted to Mr. F. Davis, of the Ministry of Agriculture and Fisheries for this instructive specimen. Previous experience of fish sarcomata seemed to

point to their relative bloodlessness as a character of general importance but, in this case, we have to deal with a true sarcoma which is extraordinarily vascular.

Fig. 12 is an outline drawing of the tail part of this fish. The latter was 38 cms. in total length and weighed 507 grams. The tumour was a very noticeable one, being about 5 cms. in length and raised about $1\frac{1}{2}$ cms. above the normal line of the body surface. It was red in colour, very soft to the feel, and not quite like anything hitherto studied. The fish was cut open with a sharp razor and it was then found that the tumour was more extensive than the external appearance indicated. The rough sections showed that it spread out beneath the skin in all directions reaching down vertically to the vertebral

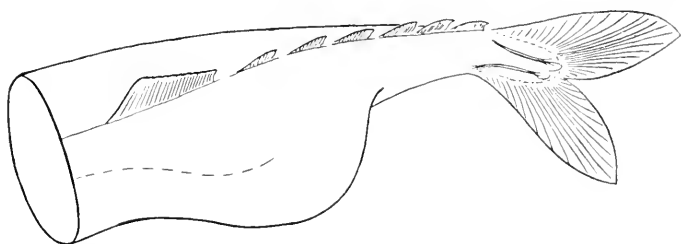


FIG. 12. Tail part of a mackerel with a tumour on the side of the body. About half natural size.

column. On cutting it open much blood escaped and so the nature of the growth was at once apparent. A small piece of the tumour was fixed in Bouin's fluid and the fish itself, with the remaining part of the growth, was preserved in 10 per cent. formalin. The fixation in the latter reagent appeared to be quite as good as that in Bouin; the sections were more easily cut, and there was far less contraction.

Fig. 13 represents a typical part of the tumour taken transversely to the long axis of the body of the fish. The blackened parts are sections of the blood vessels that exist everywhere in the substance of the tumour. It will be seen that the latter consists of a rich plexus of vessels most of which

are small, though much larger in calibre than a capillary, while some are very large and are rather irregular in outlines. The tumour is not of the nature of a "cavernoma," that is, merely a system of intercommunicating blood spaces, but is a complex of definite vessels. All these contained blood which was liquid in the smaller channels and easily escaped when the

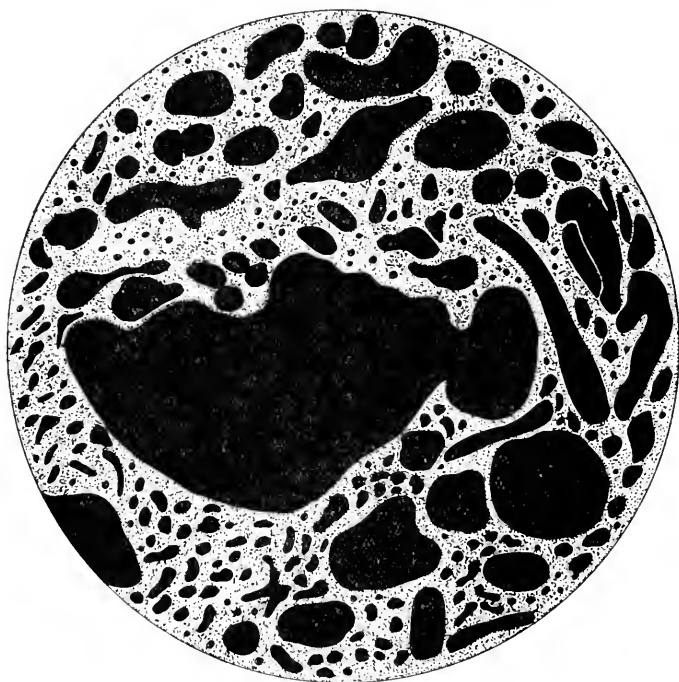


FIG. 13. Section through the tumour represented in Fig. 12. Mag. about 50 dia.

hand sections were made, but this was not the case in the larger cavities. Here, a process of thrombosis, or something similar to that, had occurred and the blood had coagulated. When the sections were stained the entire contents of these larger vessels had taken on a peculiar waxy appearance; the outlines of the corpuscles had become very indistinct, or even wholly unrecog-

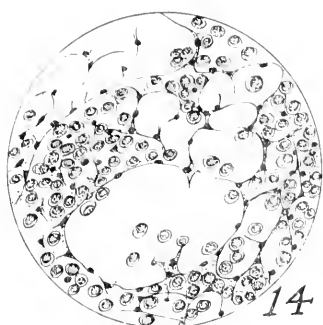
nisable, and their nuclei had ceased to take chromatic stains. Sometimes there were very obvious indications of fibrin formation in that very delicate networks could be seen in the clots contained in the blood spaces and the study of Mallory-stained sections even suggested that these clots were becoming organised. In other cases the whole contents of a vessel might become very finely granular and no other detail than this could be recognised. In places the walls of the blood vessels appeared to be breaking down and the spaces (with the clots) were being invaded from the tissue that lay between the vessels. Some of these changes may have been post-mortem ones, but it is more probable that they had begun during the life of the fish in the larger vessels of the tumour where the blood circulation had doubtless become arrested.

This extensive mass of blood vessels, with their altered or unaltered contents, is the most striking feature of the tumour, but the other feature—the inter-vascular tissue is just as interesting. What we have to deal with is a double proliferation: (1) that of the blood vessels themselves which have increased enormously in bulk so as to make up the greater part of the substance of the tumour and (2) an equally striking proliferation of the connective tissue of the part of the body involved. Both the vessels and the connective tissues have taken on the condition of malignancy—that is, they have grown locally and enormously beyond the normal needs of the body with the result of obvious tumour-formation. Then, when these processes had been in operation for some time necrotic changes had supervened with the result of the alteration of the contents of the vessels.

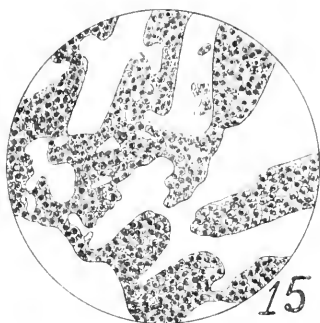
The “stroma” or connective tissue overgrowth between the vessels may now be noticed: it is represented by Figs. 14 and 15. In Fig. 15 the unshaded parts represent sections of the blood vessels (no attempt having been made to delineate the contents of the latter). The dense mass of small round

cells lying between the vessels are the stroma, and this part is shown in Fig. 13 in the finely stippled regions. Fig. 14 shows the same conditions under a higher magnification in a field where the stroma is more loosely aggregated. The blood has mostly all oozed away from the thin block of tissue taken for sectioning while the original cuts into the tumour were made. The walls of the vessels consist of a very thin endothelium containing small rather flattened nuclei, and outside this there is a delicate reticulum with small, round or elongated nuclei at the nodes. The meshes of this reticulum are crowded with small round cells of about 6μ in diameter and containing relatively large nuclei. This is the kind of tissue shown in Fig. 14 and in the stippled regions of Fig. 13.

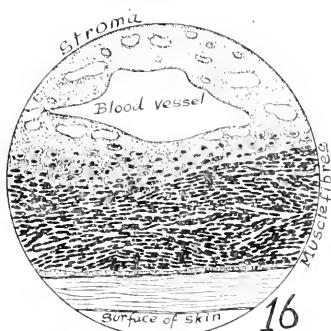
Next we consider the growing margins of the tumour. Fig. 16 shows, under small magnification, such a field having the unaltered skin at the lower surface, the fibrous layer next to this, and then the superficial body musculature (between the muscles and the fibrous layer is shown the stratum containing the silvery substance that gives sheen to the skin of the fish). The muscle fibres that are drawn in the figure are the small red ones that lie just below the skin on the sides of the body and beneath these should be the much larger fibres that constitute the really propulsive organs. None of these systemic muscles appear in Fig. 16, having been replaced by the tumour tissue. The figure shows that there is no definite boundary to the tumour and that the latter is, indeed, infiltrating the muscular tissue. Fig. 17 represents a field that has been chosen to show the proliferation of the blood vessels themselves. The stippled regions in both figures represent the stroma of the tumour and the unshaded regions the blood vessels. One large and several small vessels are seen in Fig. 16, and in Fig. 17 a blood vessel is seen breaking through from the tumour tissue into the muscular region. These figures show also the characteristic method of atrophy



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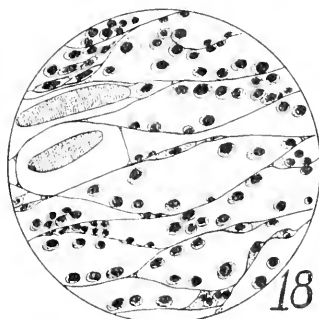
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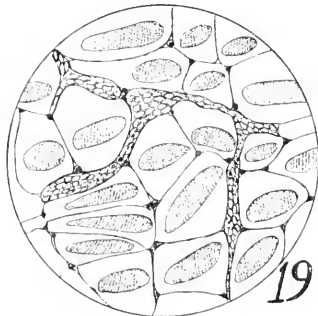
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FIGS. 14-18. Details of angioma in a mackerel.

of the muscle fibres when invasion by the proliferating connective tissue occurs: each fibre appears to become surrounded by a little empty space and it becomes smaller and smaller until it finally disappears, at the same time the abnormal connective tissue intrudes itself between the fibres and comes by and by to take the place of the latter.

Figs. 18 and 19 represent in greater detail the marginal parts of the tumour and show the method of infiltration. Fig. 19 shows a part of the margin where the muscle fibres are normal in structure and also a greatly enlarged blood capillary: this represents the vascular proliferation. In the rest of the section the muscle fibres are seen cut obliquely, and each of them is surrounded by a delicate sheet of connective tissue. Small round nuclei are situated at the angles of these sheets. This structure is quite normal. Fig. 18 is drawn to the same scale but the plane of the section passes more obliquely to the muscle fibres so that the compartments in which the latter are placed appear to be larger than in Fig. 19. Fig. 18 shows the infiltration of the muscular tissue by the stroma of the tumour and there are three kinds of cells concerned in this process. (1) The connective tissue cells that belong normally to the matrix in which the muscle fibres are placed: these appear as the small cells at the angles of the compartments. (2) Fusiform connective tissue cells such as those seen on the upper border of the field. (3) Relatively large, round cells about 8μ in diameter. Now the compartments in this figure are empty (except two on the left hand) and this means the atrophy resulting from the invasion of the muscle tissue by the sarcomatous cells.

NATURE OF THE TUMOUR.

Evidently the condition described here is a highly interesting one. We have not a simply typical angioma in the sense that the latter is a complex, or plexus, or knot of capillary vessels growing and extending into the adjacent parts

—that is a malignant blood vascular tissue. There is also a typical sarcomatous tissue which results from proliferation of the ordinary tissues that hold together the muscular parts. This tissue is normal in structure and its malignancy consists in its overgrowth far beyond the necessities of the organism and in its continued growth, proceeding as far as obvious tumour formation. In all probability this proliferation of the connective tissue framework was the initial process and then, for some reason that we do not know, followed the overgrowth of the capillaries, arrest of the rate of flow of the blood and the formation of the large and irregular blood vessels. Then degenerative changes began in the contents of the vessels with the results that have been noted. The specimen is interesting in that it gives us an example, in fishes, of the richly vascular, thin-walled sarcoma. It goes beyond this in the extent to which the blood vessels have grown so that the description “Angiosarcoma” seems to be thoroughly justified.

7. Melanism in a Herring.

The term “melanism” is, in the present stage of our knowledge, a rough and inexact one. Black or melanotic pigments exist in practically all fishes, mainly in the skin as components of the chromatophores which make up the colour patterns. Massive, abnormal deposits of black pigment are rare, but have been recorded in former Reports in this series, in sarcomatous tumours in rays and other fishes. It has also been seen in the gills and liver of fishes having melanotic sarcomata in the skin and muscles. I call this black pigment “melanin,” although I have no data as to its chemical composition. It is very stable, persisting throughout all the usual treatment of fixation, dehydration and staining of the tissues in the process of making microscopic sections. It is affected (to the extent that it may almost disappear) by prolonged treatment with hydrogen peroxide.

The instance of melanism recorded now is that of a herring examined by Mr. R. Elmhirst, of the Millport Biological Station. The fish was an immature female. The ovaries and other organs were perfectly normal in structure and there was nothing obviously unusual in regard to the skin. The fish was very fatty, both with regard to the subcutaneous and inter-muscular fat and that of the peritoneum. Its condition was excellent with regard to the edible qualities.

The black pigment was contained in the muscles, and rough hand sections showed that it was segregated in the connective tissue septa that separate the myotomes: thus, both transverse and longitudinal sections showed oblique curved lines of black crossing the muscular part of the body. Round the vertebral column the pigment was rather denser than elsewhere.

Microtome sections showed a kind of basket-work of black, fibrous tissue lying on or between the muscle fibres near the connective tissue septa. This black pigment was shown in just the same way, in the connective tissue septa themselves. It was *in* the fibrous tissue and not present in special cells of any kind, that is to say, these intermuscular fibrous elements are really blackened. There was no indication of any inflammatory process so that the diffuse melanism is the consequence of some general metabolic process and is not the result of scar, or healing tissue, formation. Further than this nothing can be said as to its genesis or significance.

8. Integumental Ulcers in Marine Fishes.

In the Report, of this series, for 1921 (pp. 287-299), there are records of cod, plaice, haddock, and soles taken in the south-west part of the North Sea and showing extensive ulcers in the skin. To the list given then I now add an instance of a female sole of 14 inches in length, mature and with ripe ovaries but showing typical ulcerated sores on both sides of the body

and exactly opposite to each other. The sores were about 2 inches in diameter. The skin was completely eroded away, the muscles being laid bare. Round the sores there were margins of about half-an-inch in width where the scales were removed. As to the causes of these integumental ulcers I have still no suggestions to offer.

9. Myxosporidia in a Hake.

In January, 1921, Mr. G. Driver, Market Inspector at Bradford, sent us a Hake which had been seized as an unwholesome article of food. Outwardly the fish appeared to be normal but close examination showed that large numbers of coiled-up Nematode worms were embedded in the flesh, while similar worms formed a layer adherent to the peritoneal wall of the body cavity.

The head of the fish was noticeable in that it showed three tuberosities, one in front of each orbit and one medially. Here the skin was abraded and the bare chondrocranium was exposed. The cartilage was full of little, opaque, white specks and each of these proved to be a mass of Myxosporidian spores. These belong to a species of *Myxobolus* similar to that referred to in the Annual Report for 1921 (pp. 299-301).

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